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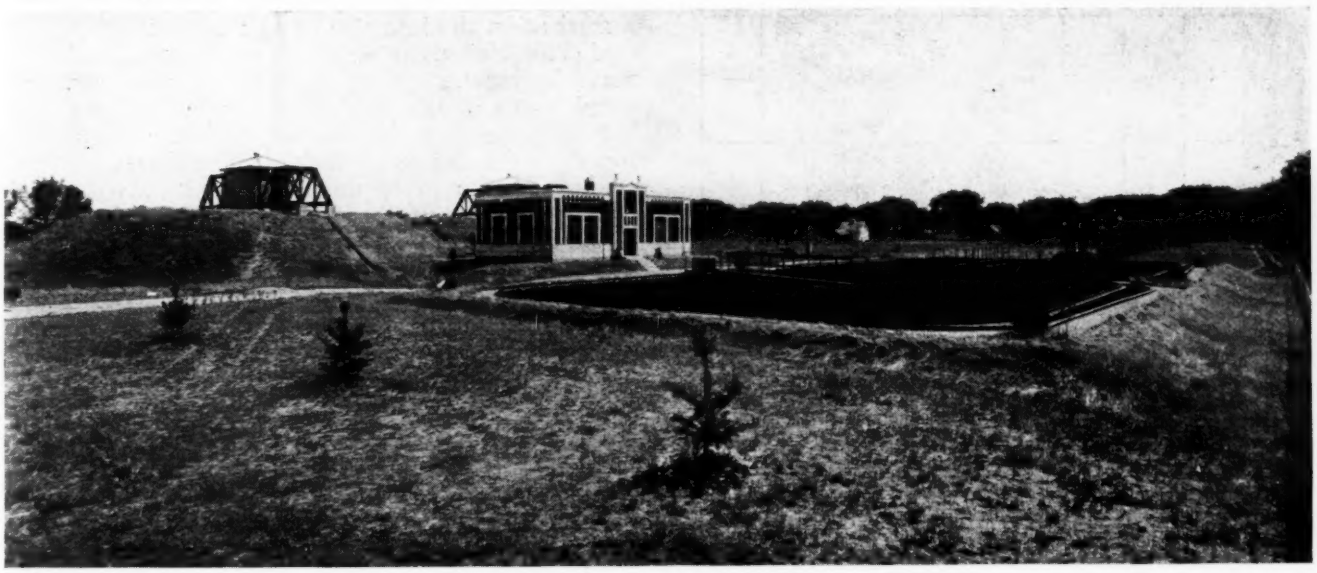

Separate Sludge Digestion Plant at Topeka, Kan. The Digesters Are Shown at the Left

Separate Sludge Digestion

A Discussion of the Development and Earlier Installations Together with a Comprehensive Study of Five Years' Operating Experience

By E. B. BESSELIERVE

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SEPARATE sludge digestion, as developed and now practiced, represents one of the outstanding achievements in sewage treatment. The theory of the digestion of sludge in a compartment separated in some degree from the compartment in which sedimentation takes place is not new. Records of plant design show that this theory probably had its first application at the Lawrence, Mass., Experiment Station, as early as 1899.

Earlier Work in Separate Digestion.—If digestion in sludge lagoons may be considered separate digestion, one may go back some years further to the work done at Essen, Germany. The first definite recorded recommendations of this method were at Paterson, N. J., in 1906, when the late Allen Hazen recommended it for that city, and the same year, in the report submitted by the Board of Consulting Engineers, comprising Messrs. Rudolph Hering, Samuel M. Gray and Frederick P. Stearns, to the City of Baltimore, Md., they advised that "sludge be removed from the sedimentation tanks at frequent intervals into smaller tanks, these to be operated as septic tanks, in which most of the solid matter of the sludge would be broken up and liquefied." Imhoff, in 1907, recognized the principle of separate digestion in his Emscher tank designs. Birmingham, England, perhaps establishes the first noteworthy example, when this method was actually adopted there in 1912, and Baltimore, Md., followed soon after.

Following the Birmingham plant, developments and modifications were made. One of these, the Kramer tank, consisted of parallel tanks inter-connected, with sedimentation and digestion taking place in different tanks. A single example in this country was installed about 1923, at Palmyra, N. J. Baltimore, Md., built the first outstanding plant, showing the trend toward the modern idea by providing a battery of tanks whose sole function was the digestion of the solids in tanks removed from the sedimentation units. George T. Hammond, Brooklyn, N. Y., in his experiments on the Twenty-Sixth Ward sewage, in 1914 and 1915, studied separate sludge digestion and reported very satisfactory results with a digested sludge equal to Imhoff tank sludge. Provisions in this plant for heating the digester and collecting the gas are early examples of this practice. Alvord introduced his type in 1914, and examples were installed at Madison, Wis., Great Lakes Naval Training Station, Ill., Lincoln, Neb., and a small town in New Jersey.

The Baltimore Installation.—All of this earlier work in separate digestion was done without true conception or knowledge of the process, and consequently the results obtained were not indicative of the ultimate possibilities. Digestion tanks were uncovered, as a rule, and were generally sources of considerable odor nuisance. As a result, separate digestion was not being favorably considered until 1917, and plants then in operation were not proving to be good arguments for the construction of others. Baltimore as previously noted

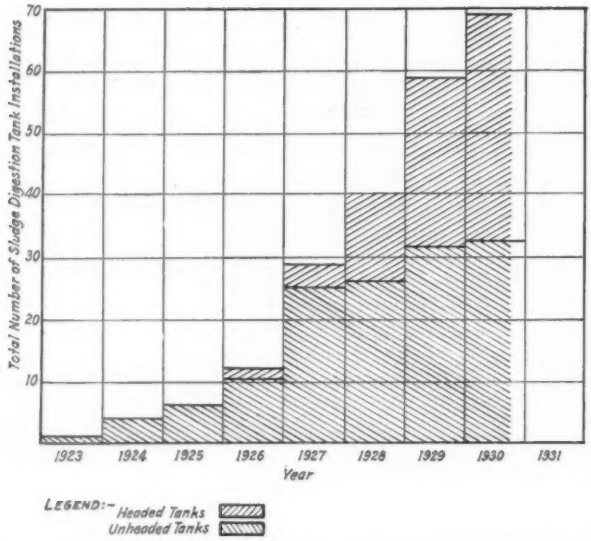


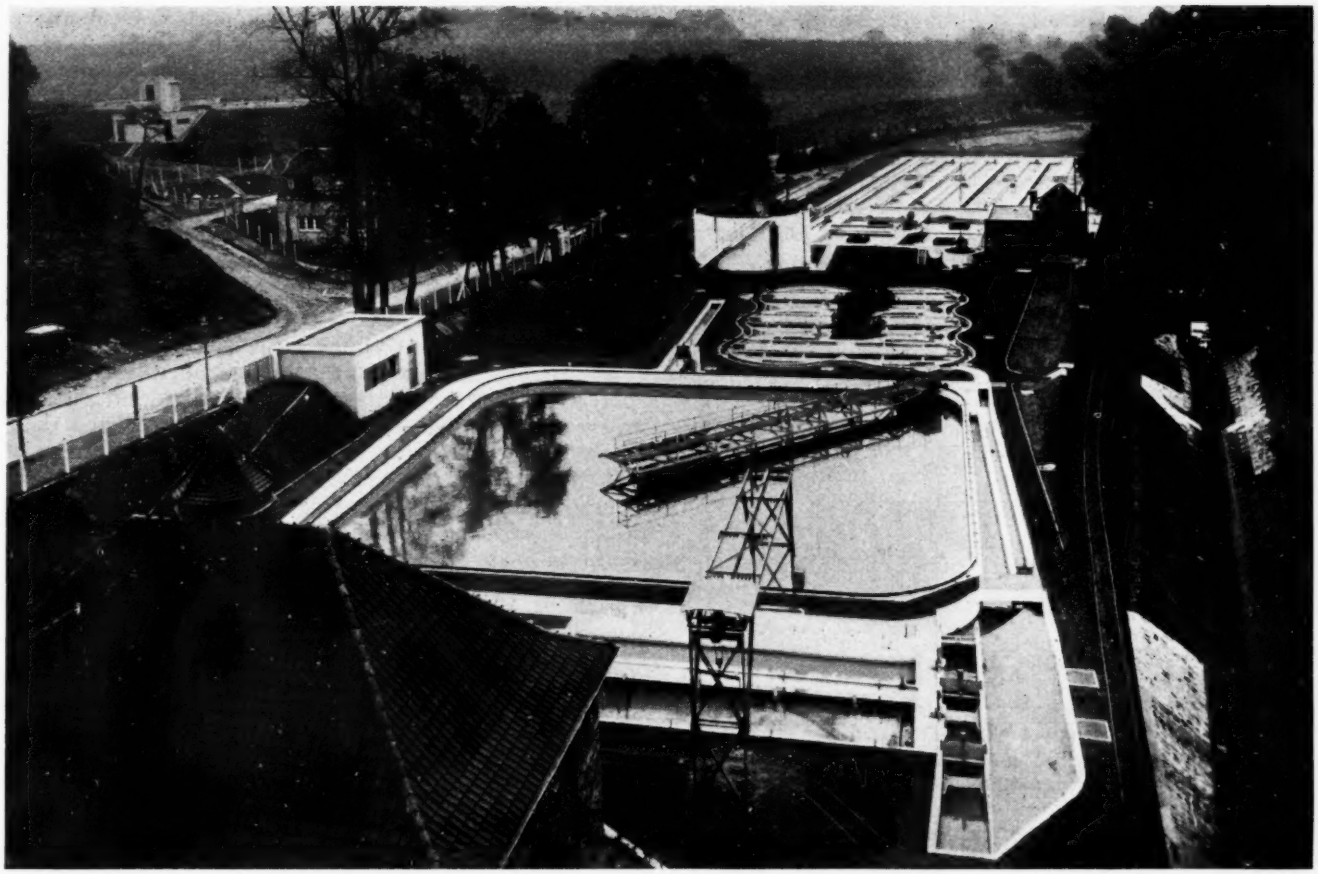
Fig. 1—Chart Showing Number of Sludge Digestion Plants With Mechanical Stirring Equipment in Operation 1923-30

is the first outstanding example of true separate digestion in the United States; that is, the first plant actually removing the sludge from the sedimentation units and pumping it to completely separated tanks for digestion, was having only indifferent success.

Per capita sludge capacities in the Baltimore plant were as much as 9 cu. ft., but the digestion tanks were not producing good results. It may safely be said that these results were due more to the method of operation than to tank design or to the characteristics of the sewage itself. The method of operation at Baltimore was to pass the sewage through the hydrolytic tanks, depositing the sludge and allowing this sludge to accumulate for ten days or more, until a depth of from 3 to 6 ft. had been collected. The tank was then drained and the accumulated sludge was pumped into a clean digestion tank. During the retention period of the sludge in the sedimentation unit, acid fermentation had set in, and all of the sludge actually pumped into the digestion tank was acid. The entire digestion tank, therefore, was filled with acid sludge, and, naturally, a long period of time was required before this sludge overcame this acid step and built up a sufficiently alkaline environment to permit the completion of digestion with the favorable characteristic of that latter step. It was perhaps in 1920 or 1922 that the idea of using shallow sedimentation tanks on sewage and providing a mechanism to clean them was first seriously considered in the United States. However, such use of shallow tanks having no space for sludge storage, and provided with a continuously operating mechanism to convey the sludge to a single outlet, made the frequent removal of this sludge from the tank a necessity. This collection occurred continuously and it was obviously necessary to remove the sludge daily in a volume equal to the amount deposited in the tanks. Therefore, it became necessary to provide a separate tank in which to place this sludge.

The Rochester Experiments.—Experiments were begun at Rochester, N. Y., in 1921, and continued for about 18 months, with a mechanically cleaned sedimentation unit and a separate tank adjacent to it for sludge digestion. Satisfactory results were obtained, which proved to be the inception of much of the research which has continued to this day and improved the process. At the Rochester plant, a stirring mechanism was installed in the digestion tank with the idea that it would produce a more intimate mixture of the raw sludge being added daily and the mass already accumulated, and possibly thereby hasten the first steps of digestion. As scum was common to the older type of sludge digestion tanks, the stirring mechanism was equipped with arms which revolved at the top, whose purpose was to break down this scum and at the same time distribute the incoming raw sludge over the entire area of the tank. Naturally, it was some time before entire success was attained. Several times the tank had to be drained and a new start made, when the entire contents became acid and odorous. Gradually, however, a study of the troubles developed the need for correcting initial acidity, and the use of various reagents was tried with varying degrees of success. After a number of discouraging trials, it was finally determined how acid-

Digester in Separate Sludge Digestion Tank at De Kalb, Ill.



Sewage Treatment Plant at Essen-Rellinghausen, Germany. The Digester Is at the Extreme Left Background. This Plant Was Remodelled Recently, When the Digester Was Installed and Also the Clarifier Shown in the Foreground

ity could be overcome by the use of proper reagents. It was also realized that one of the first principles in the maintenance of proper conditions in the digestion tank depended upon the ratio of raw sludge admitted each day to that already in the tank. It was found that raw sludge up to the maximum of 3 per cent of the total mass of the tank could be admitted each day without upsetting the progress of digestion. On this basis, this meant that a digestion tank must have a capacity of roughly 33 times the amount of sludge removed daily from a given flow of sewage by a given sedimentation unit.

Imhoff tanks had been designed for only 1.0 to 2.0 cu. ft. per capita, and fair results were obtained at a number of places, but in many places there were unexplained difficulties with foaming, heavy surface scums and belching.

The first separate digestion tanks designed on the basis of the Rochetser data contained approximately 3 cu. ft. per capita, which, although higher than the ratio provided in Imhoff tanks, did not prove excessive in construction cost, as the tanks were simple concrete cylinders with 50 per cent or more of their bulk above ground.

The Brownsville, Tex., Plant.—The first full-scale municipal plant of this type was constructed at Brownsville, Tex., in 1923, and, upon the completion of this plant, the experimental work at Rochester was discontinued. The Brownsville plant was the first plant designed entirely on this new basis. A mechanically cleaned sedimentation unit, a mechanically stirred digester and a specially developed pump were installed.

The pump was designed to draw the sludge from the sedimentation unit and discharge it into the digester at rate consistent with the collection of the sludge, and obtain the benefit of a low sludge moisture by reducing the amount of material put in the digester. As the digester was kept full of sludge and supernatant at all times, every time sludge was pumped into it an equal quantity of liquid was displaced. Low sludge mois-

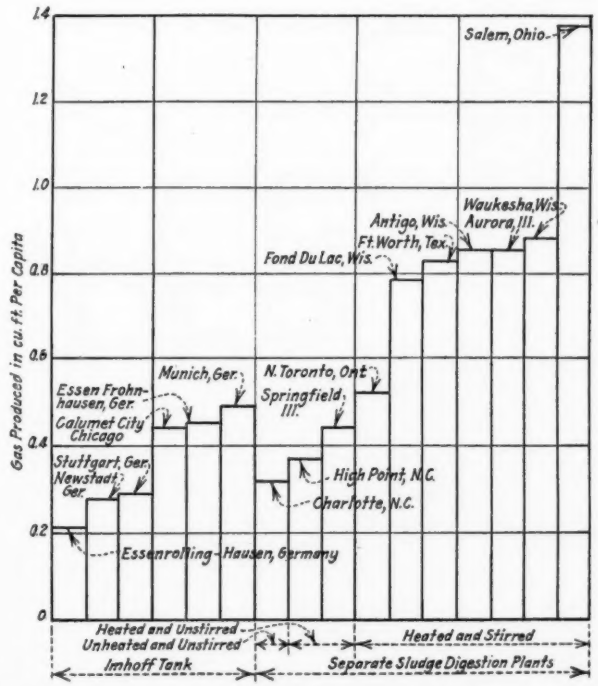


Fig. 2—Chart Showing Quantities of Gas Obtained from Various Types of Sludge Digestion Tanks

tures therefore meant less supernatant overflow to care for. This Brownsville tank was put into operation with a digestion capacity figured at 1 cu. ft. per capita on the population of 15,000 assumed to be the ultimate contributing population. This tank, with few exceptions, has given good results. It is true, of course, that the climatic conditions at Brownsville are conducive to year-round digestion, so that the digestion tank actually does not act as a dead storage tank, as was recog-

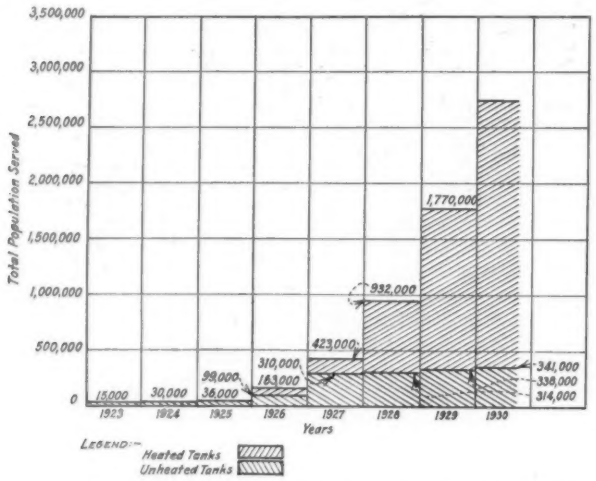


Fig. 3—Chart Showing Total Population Served by Sludge Digestion Plants Using Mechanical Stirring Equipment 1923-30

nized as being the case in colder northern climates. Other plants of this type followed in 1924, at Bartow, Fla., and in several cities in Wisconsin. These digestion tanks were designed on a basis of 3 cu. ft. per capita, realizing that from November to May there would probably be a low temperature in the digester inhibitive to digestion, and the tank must have sufficient capacity to hold a volume of raw sludge for that period. All of these earlier tanks, and, in fact, numerous others up to 1926, were of the open type, in some cases in the southern section without any covering at all, and in the northern climates some with only a board cover to keep snow and ice from them. No attempt was made to heat them or conserve the natural heat of the sludge, or to collect or utilize the gas from them.

Meanwhile, studies and investigations were being conducted, at Rutgers University by Dr. Willem Rudolfs, at Harvard by Professor Gordon Fair, and by others, also. Controlled digestion by the correction or prevention of the natural, primary step of acid fermentation, and the establishment of an environment conducive to maximum bacterial activity at all periods of the year, were the subjects of intensive research. Laboratory and small-scale experimental work proved that these two factors were the most important elements to consider and that they would make it possible to construct plants of this type with an assurance of successful results. The criterion of success was established as the production of a well-digested sludge that would dry easily and without the production of odor nuisances, foaming or scum troubles.

Heating Tanks with Digestive Gas.—Realization that an optimum temperature of 75 to 80° F. was necessary for rapid and successful digestion, even during the winter months, was the father of the idea to heat the tanks. This, however, introduced a potential item of considerable expense, because of the large amount of fuel required to heat and maintain a high temperature during winter weather, and this method of digestion control was not considered practical until it was realized that the process of digestion itself produced the necessary fuel. The gas evolved during digestion was known to be of high calorific value, ranging from 600 to 700 B. t. u. per cubic foot, but serious thought had not been given to its use in heating the tanks. Attempts to utilize this gas had been made at the Peachtree plant, Atlanta, Ga., at Austin, Tex., and experimentally at the Brighton plant, Rochester, N. Y., but only for laboratory and house heating purposes.

A few computations, based mainly on the volume of gas that had been recorded by Imhoff, about .3 cu. ft. per capita per day, showed that it was theoretically possible to heat a digestion tank with hot water coils to a temperature conducive to continued digestion by heating the water with the gas from the sludge of a given amount of sewage.

The Antigo, Wis., Plant.—The first new plant put into operation in the United States employing this principle was at Antigo, Wis., in December, 1926. The digester was equipped with mechanical stirring and provided with a tight, permanent, concrete cover suspended from the same superstructure that supported the mechanism, and with a dome for gas collection. The equipment for burning and utilizing the gas was assembled after discussion with engineers of a gas company. It consisted of a gas meter to measure the flow of gas, a flame trap to prevent back-fires from the boiler, a relief trap to prevent building up excess pressure, a gas-fired boiler of the house-heating type, a circulating pump to force the hot water into the digester, a ring of pipe in the digester to allow circulation of hot water, and an expansion tank as used in house-heating systems. This plant was started in a temperature of 18 below zero and operated in temperatures below freezing for several months. Coal was used to fire the boiler for two months, but after that time gas was being produced to such an extent that at no time since then has any outside fuel been required. Although the theoretical

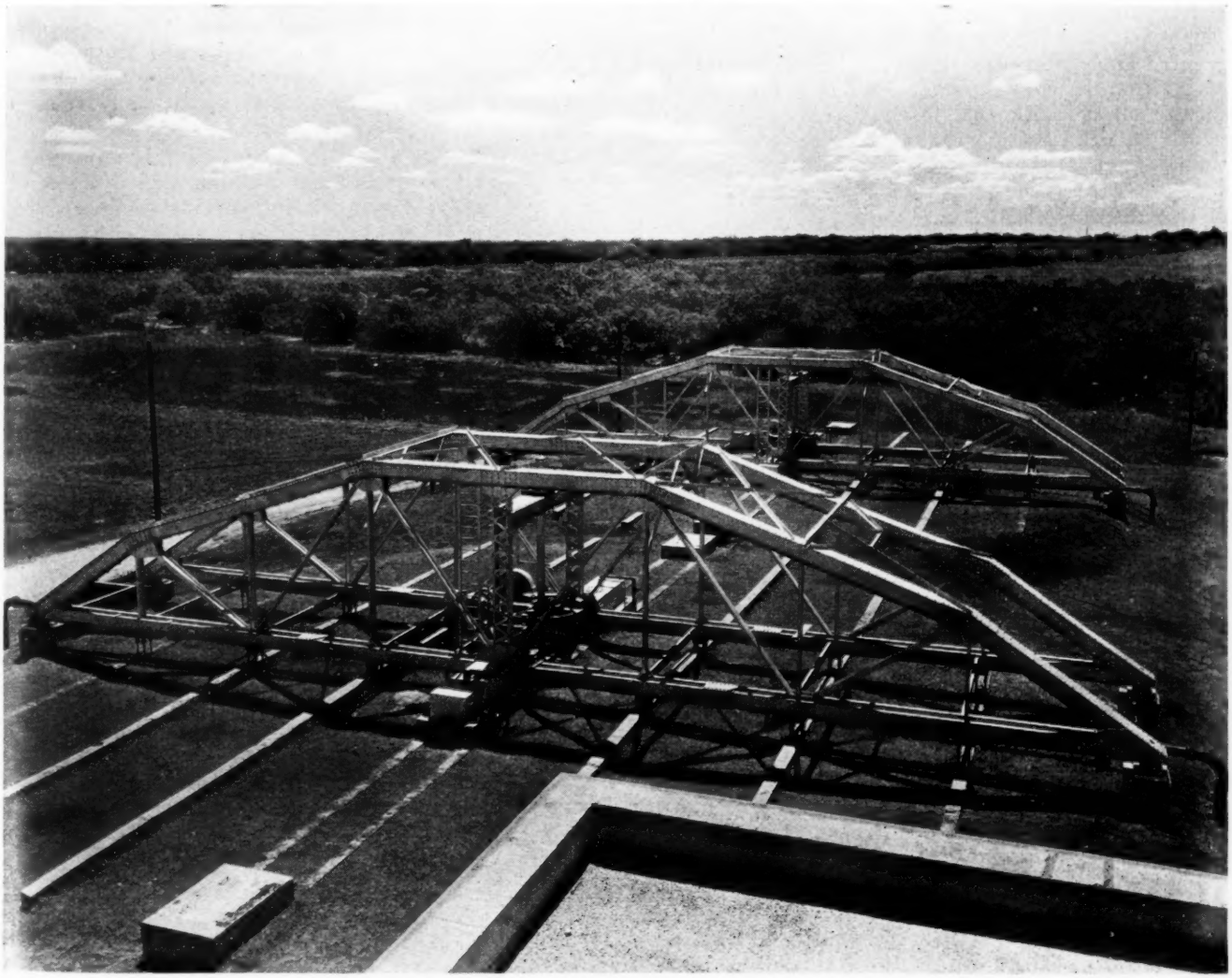
TABLE I—GAS PRODUCTION FROM SLUDGE DIGESTION IN VARIOUS TYPES OF TANKS

Location of Plant	Contributing Population	M.G.D. Sewage	Type of Digester	Gas, Cu. Ft. Cap., Day
Essen-Rellinghausen, Germany	45,000	6.0	Two-story tank (Imhoff)	0.21
Newstadt, Germany	130,000	....	Two-story tank (Imhoff)	0.28
Stuttgart, Germany	35,000	23.3	Two-story tank (Imhoff)	0.29
Calumet, Chicago, Ill.	4,400	1.4	Two-story tank (Imhoff)	0.44
Munich, Germany	500,000	50.0	Two-story tank (Imhoff)	0.49
Charlotte, N. C.	50,000	3.8	Separate, unheated and unstirred	0.32
High Point, N. C.	30,000	3.8	Separate, heated and unstirred	0.37
Springfield, Ill.	75,000	9.4	Separate, heated and unstirred	0.44
North Toronto, Ontario	50,000	6.0	Separate, heated and stirred	0.67
Fond du Lac, Wis.	28,000	3.0	Separate, heated and stirred	0.79
Fort Worth, Tex.	150,000	11.5	Separate, heated and stirred	0.83
Antigo, Wis.	6,000	0.6	Separate, heated and stirred	0.85
Aurora, Ill.	36,000	5.0	Separate, heated and stirred	0.85
Waukesha, Wis.	16,000	2.2	Separate, heated and stirred	0.88
Salem, Ohio	7,000	1.0	Separate, heated and stirred	1.38

gas production of .3 cu. ft. per capita per day had been used in computing this heating system, it was soon found by gas meter records that this rate was being exceeded greatly and that not only was sufficient gas being produced to heat the digester to the desired degree, but also to supply heat for the building.

Gas Production at Antigo Plant.—For the first year the gas production at this plant has averaged between .7 and .8 cu. ft. per capita per day. If this quantity of gas could have been sold at a low rate of 20 ct. per 1,000 cu. ft., it would have produced sufficient revenue in a year to offset the entire cost of the electrical current required to operate all the units of the treatment plant. This rate of gas production has continued right up to the present time and the records from January, 1926, to the present time show an average for this entire period of gas production of 0.8 cu. ft. per capita per day. It is noteworthy in this and other plants that the daily supply of gas is remarkably regular and dependable. Burners may be lighted in the fall and will burn continuously through the winter without attention. Naturally, during the years since the initial design, improvements have been made in the accessories. Now it is the custom to provide individual gas meters for each tank of a battery, to indicate the performance of each unit and thus judge of its efficiency. Automatic furnace control is provided, so that uniform temperature may be maintained in the digester, regardless of the outside temperature, and recording thermometers are employed which give a daily graphic record of the temperature of the hot water going into and the cooler returning from, the digester. The individual gas meters are good indices of tank troubles, because, when one in a battery is not producing the same amount of gas as the others, the operator knows that there must be some reason for that, and investigates. The recording thermometer, showing both in-going and return temperatures of the water, indicate the amount of heat being supplied and permit a check on the number of heat units required and actually applied. Another type of tank, with floating cover, instead of fixed, was introduced in 1925, and in this type it was also recognized that complete submergence of the scum, as well as covering the unit, are beneficial to good digestion and odor control.

The digester at Antigo has consistently produced such a large increase in gas per capita over any other previous type of tank, and subsequent units have sustained this record, that one is brought to the conclusion that stirring must accelerate digestion considerably. It has been a noticeable fact, recorded by independent engineers, that such tanks do not accumulate scum on the surface and that there is also a continuous discharge of gas from the surface. It is reasonable to assume that stirring the mass of sludge at the bottom of the tank tends to open up this sludge mass so that the gas



Two of the Four Digestion Tanks in the Sewage Treatment Plant at San Antonio, Tex. These Digesters Are Used for Digestion of Activated Sludge

is released as soon as formed, and that it rises to the surface in small bubbles, without sufficient bouyancy to carry up sludge particles to form scum. Furthermore, these minute passageways opened in the sludge by the gas cannot help but afford means for the passage of the active bacteria of digestion from the digesting sludge into the fresh sludge.

Odor Nuisance Eliminated.—Operation through several winters for several plants of this type indicates that many of the preconceived objections to this type have been overcome, or, in fact, have never developed. The old fear of odor so noticeable from the older type of tanks has been dispelled. Even those open tanks of the newer type operating in Florida and Texas and other places are doing so without odor nuisance in the immediate neighborhood. In practically all of the newer plants, the type of tank with fixed concrete cover and means for gas collection has been adopted, and these features have been the deciding factor in cities adopting this type of plant. So many of this type are operating successfully that cities have overcome their hesitancy in placing a sewage plant in close proximity to buildings or residences, and, with the development of expert architectural treatment of plant structures, plants have even been placed in sections where property is extremely valuable and where ten years ago a sewage plant would have been anathema.

In some cities this type has been means of saving considerable expense, as, for example, cities on the seacoast, where ocean frontage is the most valuable and yet, at the same time, is the most logical for the sewage plant. To be forced to locate the plant several miles away from the coast, as has been done, and then pump all the sewage back again to a discharge point in the ocean, entails a heavy initial expense for pipe lines and pumping stations and a heavy daily charge for pumping.

In one of the most noted and most exclusive resorts of the country, the beach front of which has been always highly restricted as a park, a plant is now being constructed, embodying all of the newer features of gas collection and utilization, and this plant is entirely below the level of the parked area, a hollow flagstaff acting as a vent being the only structure visible. A plant of this type may be built with safety and assurance of satisfactory results without nuisance to those residing nearby. It is indicative of the recent trend of thought on the part of the public that these plants are actually being built in residential and exclusive sections without protest, whereas, a few years ago, intense antagonism would have arisen.

Operating Separate Digestion Plants.—It has been suggested that separate digestion plants require too much attention. That is not a fact and is recognized now by consulting engineers in general. Many plants are operating daily, using mechanically cleaned sedimentation tanks and the mechanically stirred digesters which do not require more than two to three hours' attention a day for one man. Periodical attention to lubrication, daily removal of sludge, screenings, etc., and occasional removal of digested sludge to the drying bed are the main features of operation. When control of reaction is required, it is a simple matter to instruct the operator in the determination of the condition of his tank, and a few experiments will soon teach him the amount of reagent to add. One man can operate a plant that will handle the sewage from a large population, and the records of total annual operating cost of plants of this type are exceedingly low, as little as $1 per day for all charges, except interest on investment and amortization.

Utilization of Gas for Other Purposes.—Because of the large volume of gas being produced, as shown in Table I, the employment of it for other purposes is being considered. In summer weather, in many plants, this gas may be employed to operate electric generators, thus enabling the city to reduce or dispense with the purchased electric power for these months, thus reducing the total yearly cost. At Charlotte, N. C., this idea has been developed with some degree of success with a low gas production rate of about 0.5 cu. ft. per capita. In this city, at the Sugar Creek activated sludge plant, the gas is used to drive gas engines direct-connected to blowers which furnish air for aeration. It is understood that sufficient gas is produced to allow the operation of the blowers from 10 to 12 hours per day in these months when gas is not required for heating the tanks. In warmer climates, where it is not necessary to heat the digestion tanks at any period and where a reasonably steady flow of gas can be depended upon, this entire production could be used for power purposes, lighting around the plant, laboratory and other purposes. But, whether the gas is utilized or not, a gas collection digester, with completely closed cover and tight dome, is warranted, in the author's opinion; for the simple reason that the gas, which is the sole disseminator of odors, is thus always under control in pipes and may be burned simply as a means of disposal. Burning the gas assures the permanent destruction of all odors. This is now being practiced at a plant in New Jersey, where the gas is burned in the stack of the plant and no complaint from odor or nuisance has arisen from neighbors, after operation for almost a year.

The increasing desire for plants of this type is the best index of their success. The number of plants of this type installed and put into operation since 1923, and the ratio of each year's plants to the total, as shown in Table I, indicates the extent to which separate digestion has taken hold in this country and abroad. It is especially interesting to note that plants of this type have been built in Germany and other European countries by engineers whose earlier developments have been along different lines.

Another year will produce records of operation of almost one hundred plants of the separate digestion type and will be a valuable addition to the recorded data of sewage treatment. Five years' experience is a sufficiently long time to bring out inherent difficulties, if they are likely to develop at all, and it is firmly believed that separate digestion is now on a firm footing of fact and knowledge and may be applied with safety to the handling of settled solids from sewage, whether from raw sewage, activated sludge or trickling filter humus tanks.

Acknowledgment.—The foregoing is a paper presented Oct. 15 at the annual meeting of the American Society for Municipal Improvements.

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DALLAS, TEX., ADOPTS CITY MANAGER PLAN.—On Oct. 14 the citizens of Dallas, Tex., by a 2 to 1 vote adopted amendments to the city charter providing for a commissioner form of government. The new city manager will be chosen next April by a council of nine. Dallas, with a population of 200,000, is now the fifth largest city in the country under the manager form of government.

Changing from a Flat Rate to a Meter Basis

Methods Used by City Water Department of Gloversville, N. Y., to Bring About the Adoption of Universal Meterage

By ALEXANDER ORR

Superintendent, Board of Water Commissioners, Gloversville, N. Y.

ENGINEERS and superintendents generally recognize that the meter basis is the only practical business way to obtain revenue from the sales of their products.

Public utilities owned and operated by corporate or private interests universally sell their product on a measurement rate basis and are always in a position to know the exact relation between earnings and output or product for said earnings. On the other hand, municipally operated utilities selling their product on a flat rate basis never know the relation between these two items.

Gloversville has a population of about 23,000 and its principal industries are the manufacture of gloves and the production of leathers of all kinds.

Its water supply system is municipally owned and is a gravity system obtaining its supply from mountain streams in the foothills of the Adirondack mountains. It has a reserve capacity in its storage works of approximately 400,000,000 gal.

The water department of the city is under the charge and control of a board of water commissioners of five members who are elected by the city at large for a term of four years. Its duties and rights are prescribed by a special act of state legislature creating the board.

When the writer became connected with the water department in 1899, the department was facing an acute shortage of water, the storage capacity of the system at that time amounted to approximately 18,000,000 gal. and the end of this reserve supply was in sight. Only the early appearance of a rainy season saved the city from serious consequences.

Water Demand Increased by Change in Manufacturing Process.—About this same time a radical change had been brought about by the leather manufacturers in the methods and processes of tanning and dressing leather. Prior thereto the time consumed in producing finished leather from the raw stock was from 2 to 18 months. New processes of tanning and dressing were perfected so that at the present time the same leathers are produced in from 6 to 14 days and of a much finer quality in every respect.

The city water is very clear and soft. The total hardness runs from 22 to 30 and is claimed by leather dressers to be the finest water for leather dressing purposes in the world. Due to its softness and relative freedom from minerals in solution the tanners are able to produce leathers of the finest texture and finished in the softest shades of all colors.

This change in the methods of dressing leather increased very greatly the amount of water used by the tanners and in order to preserve the industry to our city it was immediately necessary that the board of water commissioners take steps to provide the necessary additional supply.

At this time the city had already taken over and was using all the available sources of supply and the only method left to increase the water supply was the development of storage works on one or more of the streams supplying the city. The board immediately made plans and took steps to carry out a building program looking to the creation of additional storage capacities and enlargement of city mains to make such additional supplies available.

At the same time the board was strongly impressed with the fact that steps should also be taken to prevent the loss by waste of such supplies and that the daily consumption should be reduced as nearly as possible to legitimate and proper uses.

Cutting Down Water Waste.—House to house inspections had been periodically made for some years past and the tabulated results from such inspections always revealed that from 50 to 75 per cent of all service pipes had one or more leaky fixtures connected therewith. Orders to repair forthwith served on the owners of the properties affected would bring about some immediate response, but generally there was a neglect in repairing the defective fixtures and the board soon became convinced that the house to house inspection was of little use and decided that the only way to conserve the water supply was to adopt the meter system.

At this time the board had in effect a classified meter service which compelled all service pipes leading to manufacturing plants, hotels, livery stables, laundries and business blocks to be metered. This classified list had been in effect for some years and about 300 meters were in use.

The First Step in Combatting Opposition to Meterage.—In arriving at the conclusion as stated the board realized that there would be serious opposition from certain interests against universal meterage as soon as their plans became generally known. As one step to combat this opposition they decided to buy 100 meters, to be placed on domestic services where it was thought the effect would do the most good for the plan. Very often some property owner having a small family would object to the water tax he was paying under the flat rate as compared with some neighbor with a large family, who was paying the same rate. Here it was suggested to him that he have a meter placed on his service pipe and thus pay for his actual use. Instances of this kind, together with applications for meters from others who were interested in the proposition, soon used up the hundred meters and the board was obliged to buy more to meet such requests.

The next move was to add to the classified list all service pipes leading to boarding and lodging houses.

A further study of the tabulated results of house to house inspections showed that one particular type of fixture, the hopper closet, was a serious waster of water and that there was about 500 of these in use. The board immediately ordered meters placed on all service pipes leading to properties having such closets.

The board then passed a resolution and ordinance requiring all new and all re-placed service pipes metered. This resulted in 100 to 120 additional meters each year.

Results of Meter Installations Bring General Ordinance.—In 1907, the board, after a study of the results of the meter installations as heretofore cited, enacted and passed a general ordinance requiring all service pipes connected to the water supply system of the city

to be metered, that all water supplied to said service pipes be at the existing schedule of meter rates, and that the meters necessary to carry out the foregoing ordinance be bought and installed as fast as the finances of the department would allow.

This action started the fireworks. Letters and newspaper articles appeared in the daily press from the opposition. These articles were met by articles written and published by several consumers who had had for some time meters on their service pipes and gave encouragement to the board to proceed along the lines settled on. Some of the articles from the opposition were answered by the board giving a general description of the waste of water on specified premises and described in such a way that everybody knew who owned such properties without naming the specific objector. One such objector who made the biggest howl came out in the press with a letter stating that he had investigated the meter proposition in reference to a number of cities and that all of the cities mentioned the adoption of meters would not be tolerated. The writer immediately got in touch with the water departments of the cities referred to and immediately received replies that the meter system had been adopted and that meters were required on all service pipes and that those not yet metered were gradually being metered. This objector's original letter was then again published together with the replies received by the writer from the cities referred to and no further opposition came from this objector's camp. The last wail of the opposition was to conduct a voting contest on the question of adopting meters in the daily press by means of a coupon to be filled out and mailed. Of course, these coupons were filled out and mailed in by everybody no matter whether they were city or rural residents. However, before the final count was made (if it ever was) the city water works system was 70 per cent metered and water consumers were still asking for meters on their service pipes of their own volition.

The final work of metering unmetered services was carried out by taking one street in each of the six wards and ordering and placing meters on service pipes not already metered. This method was repeated from time to time until all the city was covered. On Jan. 1, 1913, the water board was able to report the city 100 per cent metered.

The Schedule of Meter Rates.—The schedule of meter rates in force up to 1909 was based on an average daily consumption and was in terms of gallons. This schedule was found to be in many cases unfair and cumbersome and in 1909 the following schedule was adopted:

	Cents per 100 Cu. Ft.
For the first 5,000 cu. ft.	12
For the next 5,000 cu. ft.	10
For the next 5,000 cu. ft.	8
For the next 5,000 cu. ft.	6
For the next 5,000 cu. ft.	4
For the next 5,000 cu. ft.	3
For all over 30,000 cu. ft.	2½
Minimum charge per meter for 6 months	$2.00

The above schedule was in effect until 1917 when the last two items of the schedule were eliminated making all water used over 25,000 cu. ft. at 3½ ct. per 100 cu. ft.

Effect of Meterage.—As to the effect of installing meters on domestic services we find that generally 80 per cent of such consumers saved money or broke fairly even as compared with the old flat rates. The other 20 per cent paid for what they used and wasted and more than made up for the loss due to the savings of the other 80 per cent. Any suggestion today in the city of Gloversville to return domestic consumers to a flat rate schedule would not be tolerated by the majority of such consumers.

Under the former flat rate system water taxes were collected from the whole city every six months in May and November. As the number of meters set began to increase it soon became evident that the billing work, etc., connected with meter accounts would make this method cumbersome and impracticable. The city was, therefore, divided into three collection districts, each district collected every six months and thus giving a collection in the office every two months. This change simplified the work and keeps a steady stream of work going through the office and a steady stream of money coming in. The entire work of figuring, billing and collecting water taxes together with all other clerical work of the department is done by 2 people.

The entire work of reading, setting, replacing and repairing of all meters is done by 3 men. At the present time we have 5,230 meters installed, all read four times a year, twice for collection and twice for checking.

In conclusion, the writer from his experience believes that all communities are alike to a great extent, the proportion of fair minded tax payers is in a majority, the opposition to be met against a meter rate basis is due largely to ignorance on the subject and a small amount of education will swing this opposition to support. There will always be opposition, however, from certain elements who know that under the meter basis they will have to walk up and settle in full for what they are receiving to a great extent free under the flat rate schedule.

In Gloversville today and for several years past we do not know or fear a water shortage. We are satisfied that the universal adoption of a meter basis in our city has been a great factor in conserving our supply and bringing about this condition.

Acknowledgment—The above is an abstract of a paper presented before the New York section of the American Water Works Association.

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Furnishing Water to Contractors

In a discussion in the Superintendents' Round Table at the St. Louis convention of the American Water Works Association, Mr. C. W. Winkle, superintendent of maintenance and transportation, Indianapolis Water Co., state that his company furnishes water to contractors from fire hydrants, but it is under the supervision of one of their employees. A 2-in. valve connection is put on one of the nozzles of the hydrant, the hydrant opened up full and then the contractor operates the hydrant from the 2-in. valve which is reduced down to about, in most cases, a 2-in. opening and the water company man looks after this contracting work and closes and opens them at nights and mornings. The fire department is notified where these hydrants are equipped with the contractor's connection. If it is on a street that has been blocked off for several squares the company does not close it up each night and open each morning until the contractor gets through. The fire department is prepared for the contractor should they have to get into the street. They understand that when they get to this hydrant with the 2-in. valve connection on the 2½-in. nozzle they first have to close the hydrant before they can make connections thereto. Very good results have been had in this way of handling contractors.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Air-Binding of Filter Beds

VERY few filter beds are free from air-binding troubles all the time, and while the release of air in the sand beds is not a serious problem in most filtration plants, it proves quite troublesome at times in a few plants. It is well known that water exposed to the air contains dissolved gases. The saturation points of the various gases in contact with water have been worked out years ago, and have been described fairly well in the chemical literature. Equations are available for computing most of the variations due to changes of conditions, so that saturation equilibrium can be calculated for most any condition. There is one thing that has to be determined experimentally, and that is the amount of gas that will dissolve in water at some given temperature and pressure. When this is determined for one condition it can be calculated for most any other condition.

As many of the engineers and chemists engaged in water treatment may not have all this information readily available, it is believed desirable to review some of the well known facts. This may seem somewhat elementary to advanced chemical students, but owing to the fact that air-binding is a factor almost ignored in the design of filtration plants, there is some justification for thinking perhaps many of those designing and operating such plants are none too familiar with the fundamentals of air-water equilibrium. Much of the present article will be arranging known chemical facts in a form more suitable for general use in water filtration, hoping that it will not be necessary for the reader to make extensive search of the literature.

Chemical Laws Governing the Solution of Gases in Water.—As stated, there is no law to predict the quantity of a given gas that will be absorbed by water, but once its equilibrium has been established for one condition the influence of temperature, pressure, and the presence of other gases may be computed fairly accurately.

Avogadro's law states that equal volumes of all gases under the same condition of temperature and pressure contain the same number of molecules. The molecular weight of oxygen (O_2) is 32, and a molecular (one mol) volume of gas is the volume of 32 grams of oxygen. The molecular (mol) weight of a gaseous substance is that weight which occupies a molecular (mol) volume. At 0° C. and 760 mm. of mercury (one atmosphere), the volume for one mol of oxygen (32 grams) is 22.410 liters.

Boyle's law states that at any constant temperature the volume occupied by a quantity of gas is inversely proportional to the pressure exerted upon it. The pressure in atmospheres multiplied by the volume of a mol weight equals a constant.

The usual chemical method of expressing the composition of a mixture of gases is in terms of the mols of each substance present. The air is approximately 23.25 per cent by weight of oxygen, 75.50 per cent nitrogen, and 1.24 per cent argon. Reduced to mol ratios, each mol of air contains 0.210 mol of oxygen, 0.781 mol of nitrogen, and 0.009 mol of argon.

Dalton's law states that in a mixture of gases each exerts its pressure independently of the others; that is, the partial pressure of one gas is unaltered by the presence of another gas which also exerts a partial pressure. To illustrate: if two liters of nitrogen gas at atmospheric pressure are mixed with one liter of hydrogen gas at the same pressure, there will be three liters of the mixed gases, which will be two-thirds nitrogen by volume and one-third hydrogen. The nitrogen will exert two-thirds of the pressure and the hydrogen one-third. According to Avogadro's law the mol ratio of the mixed gases will be 0.667 and 0.333 respectively and each gas will exert a partial pressure in proportion to its mol ratio. Another illustration might be given in which one liter of nitrogen gas at atmospheric pressure is forced into a vessel that contains one liter of oxygen at atmospheric pressure. The combined pressure will be 2 atmospheres, for each gas in the vessel will exert independently of the other a pressure of one atmosphere. Forcing another liter of some other gas into the vessel will produce a pressure of 3 atmospheres, each of the three gases exerting independently a pressure of 1 atmosphere.

Henry's law states that the solubility of a gas at a given temperature is proportional to the pressure of the gas above the solution. This means that if a certain volume of gas is absorbed by a liter of water at atmospheric pressure, twice the amount will be absorbed at a pressure of 2 atmospheres. One atmosphere is equal to a head of 33.93 ft. of water, and each foot of head or each foot of suction increases or decreases respectively the amount of gas which will be absorbed by approximately 2.95 per cent.

These chemical laws may not be absolutely correct for all conditions, but are so nearly accurate there will be no appreciable error in using them in computing the solution equilibriums of gases in water. The charts in Fig. 1 and 2 illustrate the effect of temperature and pressure on the absorption of gases by water.

Solubility of Gases in Water.—The solubility of gases in contact with water at 0° C. and 760 mm. of mercury (one atmosphere) are given in Table I. This is based upon the water being in contact only with the gas being absorbed.

Determining the Gas Saturation Equilibrium.—To illustrate how the gas saturation equilibrium may be determined for any given condition, we will assume the water in a certain stream at a temperature of 5° C. is

Table I—SOLUBILITY OF GASES IN WATER AT 0° AND 760 MM. MERCURY

Gas	Volume in CC. of Gas per Liter of Solution	Weight in Grams of Gas per Liter of Solution
Oxygen	48.90	.06948
Hydrogen	21.48	.00192
Nitrogen	23.88	.02977
Chlorine, 10° C.	3,095.00	9.969
Carbon monoxide	35.37	.0440
Carbon dioxide	1,703.00	3.347
Hydrogen sulfide	4,686.00	7.100
Ammonia	1,298,900.00	987.00
Sulfur dioxide	79,789.00	228.30
Methane	55.63	.0396
Ethylene	226.00	.2810
Acetylene	1,730.00	2.000
Air	28.81	.0372

saturated with air. Water from this stream is used in a filtration plant, and in passing through the treatment process before it reaches the filters the temperature is increased to 10°. The curve for air in Fig. 1 shows the saturation equilibrium to be 25.5 cc. of air per liter of water at 5°, and 22.5 cc. at 10°. This is 3 cc. in excess of the saturation point, or 13.3 per cent supersaturation as a result of the increase in temperature. It might be well to state that the saturation point of air in water at 0° C. is approximately 38.8 cc., or 37.2

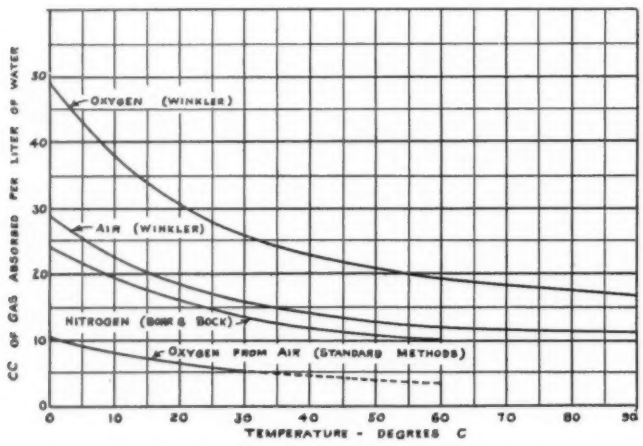

Fig. 1—Relation Between Temperature and Volume of Gas Absorbed

parts per million, and not 63.8 parts per million as given by Ellms[1].

We will assume that the filters in this plant were constructed for a total loss of head of 10 ft., with the water level about 5 ft. above the top of the sand beds. Assuming 1 ft. loss of head as friction through the sand and the underdrains when the filter is first put in operation after being washed, this allows a suction of probably 3.5 to 4.5 ft. to be exerted on the water in passing the beds when the losses of heads are at the maximum. The chart in Fig. 2 shows that for 4 ft. suction, the equilibrium of air at 10° C. is 19.7 cc. Taking into consideration both the effect of temperature increase and suction, and computing the excess of air as being the difference between the original saturation equilibrium and its equilibrium under maximum suction in the beds, the supersaturation is about 29.4 per cent. It is evident that such a condition will produce serious air-binding troubles.

In most filtration plants, and especially the larger ones, there is little or practically no increase in the temperature of the water in passing through the plants, but there are a few cases where the temperature does increase. Very likely there are cases where the water increases in temperature on warm days in storage reservoirs prior to filtration and causes the water to become supersaturated with air. In a few plants the water is passed over steam engine condensers, which increases the temperature several degrees.

Conditions That Cause Water to Become Supersaturated with Air.—When water is saturated with air at atmospheric pressure, the factors that cause supersaturation are as follows:

1. Increase in temperature.
2. Decrease in pressure.
3. Increasing the pressure while the water is in contact with air bubbles, causing more air to dissolve, then reducing the pressure to normal.
4. Formation of gases within the water as a result of chemical or biological action.

The effect of temperatures is illustrated by the curves in Fig. 1. The effect of changing the pressure follows Boyle's law and is illustrated in Fig. 2.

Increasing the pressure while the water is in contact with air bubbles is typical of what happens in a few plants where the water is pumped in advance of filtration. Where the water going to the pumps is under suction, it is difficult to avoid air leaks in the suction pipes or the packing glands of the pumps. Then when the air bubbles pass the pumps and are thrown under pressure the bubbles go into solution, tending to establish an equilibrium for the increased pressure should enough air be present. When the pressure is released in the mixing basins and the settling basins of the filtration plant the water may be considerably supersaturated with air.

There are several references in the literature to supersaturation of water with air due to air bubbles getting into the water and the water immediately afterwards forced under pressure. No doubt there are many other known cases as well as many cases where this is the cause but is not known. Hatfield[2] describes serious air-binding of filter beds at Highland Park, Mich., due to leaky packing glands on a pump. Fields[3] also describes a similar cas. Leak in the suction lines to pumps is not the only way air bubbles may get into the water. The writer[4] gave account of a case where water was allowed to fall into a chamber that led into a tunnel which was under about 35 ft. head of water. Air was churned up in the water as it fell into the chamber, and the chamber being small the bubbles were carried on into the tunnel with the water. The saturation equilibrium of air in water under 35 ft. head of water is more than double the equilibrium at atmospheric pressure, and it is likely that the bubbles went into solution quite readily.

More air-binding, it seems, is attributed to microorganisms causing a supersaturation of oxygen in the water than anything else. As to the correctness of this assumption, there is considerable doubt in the mind of the writer, for many plants where the microörganisms are so few that they could not possibly increase the dissolved oxygen materially there is considerable air-binding at times. The increase in dissolved oxygen very likely is a contributing cause in a number of plants. Powell[5] states that air-binding is more frequent in winter than in summer due to the water increasing in temperature in passing through filtration plants. He also states that when there is air-binding in the summer it is traceable usually to prolific algae growths, and that under some extreme conditions the supersaturation of dissolved oxygen may rise to 200 per cent. The writer has never come in contact with water used for a public supply that had more than a slight excess of dissolved oxygen due to algae growths, but does not question the

statement that such organisms cause the water to be greatly supersaturated with dissolved oxygen in some waters.

Influence of the Supersaturation of One Gas on the Saturation Equilibrium of Air in Water.—As many filter plant operators attribute most of their air-binding troubles to increases in the dissolved oxygen due to algae being present in the water it might be well to see what influence increasing the oxygen has on the saturation equilibrium. Perhaps some get the impression that a certain per cent excess of oxygen represents that much supersaturation. This is not the case. Assume a 20 per cent excess of dissolved oxygen over the amount normally in the water, and assume the temperatures to be 10° C. Computing the dissolved oxygen from the table given in Standard Methods of Water Analysis, there is approximately 8.0 cc. of dissolved oxygen at this temperature when the water is at equilibrium with the air. Twenty per cent excess would be 1.6 cc. Now if we could assume that this excess was air it would be easy to calculate the supersaturation to be approximately 7.1 per cent, but the gas escaping in the sand beds would not have exactly the composition of the gases of the air. The oxygen ratio would be slightly higher, and as oxygen is more soluble than nitrogen the saturation equilibrium would be different. Instead of the supersaturation being 7.1 per cent, it would be somewhat less. With highly soluble gases such as carbon dioxide a material increase in the amount of carbon dioxide in the water does not increase the supersaturation of air very much.

The Point Where Air Is Released in Filter Beds.—It must have been the opinion of a few some years ago that air is released in the gravel of the filter beds, for we find Caird[6] stating that: "The voids in the gravel are greater than in the sand, therefore the air collects in the gravel." As a matter of fact the air first collects in the sand and it is only under very extreme conditions where it extends down into the gravel. The writer has made many observations on the release of air from water in glass tube filters, and finds that the first air always occurs near the surface of the sand beds, frequently less than 1 in. below the surface. Is this not the place where we should expect it to start? It is the point where there is the greatest suction head, also the point where the air remaining in the bed in the form of small bubbles that are not washed away during the washing period usually collect. It will be explained later that the release of air under conditions occurring in filter beds cannot start without the presence of air bubbles or a gas surface to give a starting surface.

Negative Head in Filter Beds.—If a filter bed shows a loss of head of 1 ft. when first put into service after washing, probably three-fourths of this loss is friction through the sand and gravel, and the balance is through the underdrains. Of the loss in the sand, it is believed that approximately one-half is within the top 2 in. of sand. Practically all increase of loss of head as the filter continues in service is in the top of the sand beds. It never increases materially below the point where the coagulated matter is deposited, which usually does not penetrate into the beds much more than 2 or 3 in. except when the water is near the freezing point. It might be said that for most filtration plants there is practically no increase in the friction losses below the top 2 or 3 in. of sand, except possible for a short period during the colder months in a few plants. Even then the major portion of the increase is in the top 3 in. These statements apply to portions of the sand beds free from surface or side cracks.

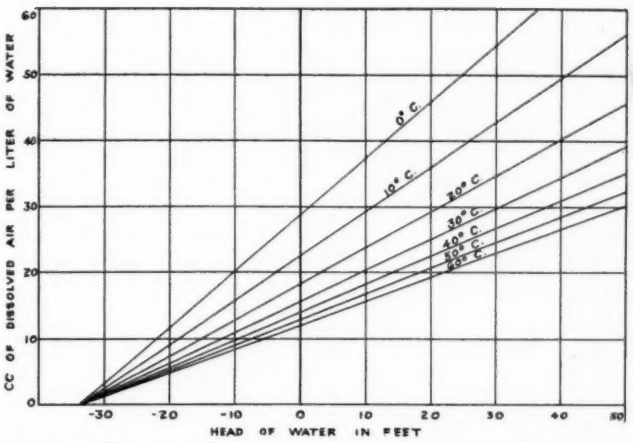

Fig. 2—Effect of Pressure on the Air Absorbed by Water

Fig. 3 shows profile of the pressure on the water as it passes through a filter, using atmospheric pressure for the zero line WA. In this case the sand surface is assumed to be 4 ft. below the water level, and is at the vertical line through S. D is the line at the underdrains. The total loss of head on the filter is assumed to be 1 ft. at the start of the run and 8 ft. at the end of the run. It will be assumed that the valve on the effluent line is 10 ft. below the water level on the filter. When this valve is cut off the head on the water below the water surface is a straight line WX, and when the filter is put in operation the head follows the line WSDT. The line WS to the sand level is always the same and is always above the zero line, but SDT keeps dropping down as shown by the line $SS_1D_1T_1$ as the loss of head increases. If the water is just saturated with air there will be no escape of air so long as the point S_1 does not fall below the atmospheric line WA. The condition shown in Fig. 3 is characteristic of every filtration plant. As the distance from the water surface to the sand surface varies the curve for head on the water shifts along the line WX. S may be found at most any point along the line in various filtration plants. If S is at the 8 ft. line; that is, 8 ft. below the surface of the water, there will be no negative head when the total loss of head is not over 8 ft. Supersaturation of the water is equivalent to shifting the point S towards W, and when the water is less than saturated it is equivalent to shifting S towards X.

Computing the Volume of Air that May Be Released in a Filter Bed.—A rapid sand filter bed of 1,000,000

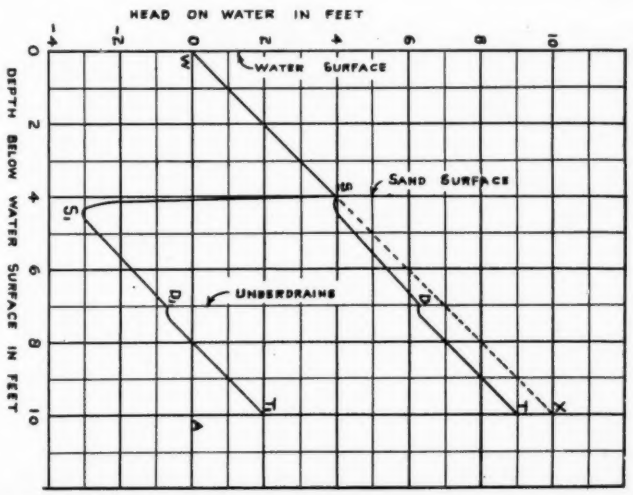

Fig. 3—Head on Water as It Passes Through a Rapid Sand Filter

gal. capacity, when operated at the rate of 2 gal. per square foot per minute, will have approximately 347 sq. ft. of filtering surface. Assume the voids in the sand that may become filled with air to be about 30 per cent of the volume, this will give about 104 cu. ft. of voids for each foot of depth in the bed. When the water at 10° C. is just saturated with air, a suction of 1 ft. on the water will supersaturate it to the extent of 0.685 cc. per liter, or 0.000685 per cent of the volume of the water. This is determined by the line for 10° in Fig. 2. For 1,000,000 gal. of water this would give 685 gal. of air, or 91 cu. ft. This is approximately 3.8 cu. ft. of air supersaturation per hour per 1,000,000 gal. capacity at 1 ft. suction when the rate of filtration is 2 gal. per square foot per minute. If all the supersaturation was released in the sand bed, which most likely it will not be, this would fill the sand voids to a depth of 0.036 ft. per hour, based upon an even distribution of the air throughout the bed. With 3 ft. suction the air released, if all the supersaturation was released, would be 0.108 ft. per hour, or 11.4 cu. ft. Assume only one-half of the supersaturation is released, which probably is more near what actually takes place, and assume the filter ran for 4 hours with a negative head of 3 ft., about 22.8 cu. ft. of air for the four hours might be expected. This is enough air to cause considerable bubbling when the filter is cut off to be washed, and to cause the unsightly foam to collect on the surface of the water during the washing. Not only is the foam unsightly, but it carries away considerable sand with it.

The conditions just explained probably are somewhere near actual conditions that are likely to occur in most any filtration plant where a negative head is produced in the upper part of the sand beds before the loss of head reaches the maximum. As the water in flowing through is only a very short time within the location where there is negative head, it is evident that the rate at which the air will be released is of importance.

Rate of Air Release in Supersaturated Water.—What are the factors which govern the rate at which air will be released from water? There is not much information on this subject. Whitman and Davis[7] confirm Bohr's conclusions that the rate of escape of sulfur dioxide from water is about the same as the absorption rate. Very likely this is true, or nearly true for all gases. As absorption of gases has been given more study than the escape of gases from water, it might be well to review some of the work on absorption rates.

Lewis and Whitman[8] state that when a liquid and gas come in contact in a quiet state there exists on the gas side of the interface a layer of gas in which motion by convection is slight, and that similarly on the liquid side of the interface there is a surface layer of water which is practically free from mixing by convection. Any transfer of gases through the films must be by the very slow process of diffusion. These authors also state that with gases of low solubility such as the gases found in the air, the gas layer at the interface has no appreciable effect and the absorption rate is determined by the layer of liquid on the liquid side.

Perhaps many are not aware that the thickness of the layer on the surface of the water varies considerably, depending upon the time it has stood in contact with the air. Mr. Frank Hannan several times has called the writer's attention to the very thick surface film formed on the water surface after it has stood in contact with the air for a short time, and has stated that the transfer of gases through this film is extremely slow. Lewis and Whitman give the formula

$$\frac{dW}{dO} = K_L A (C_s - C_L)$$

for the absorption rate of gases.

$\frac{dW}{dO}$ = rate of absorption in grams per hour.

W = weight of gas absorbed in grams.

O = time in hours.

A = area of liquid-gas interface in square centimeters.

K_L = diffusion coefficient through liquid film.

C_s = concentration of the gas in water in equilibrium with the gas, in grams per cc.

C_L = concentration of the gas in the main body of the water, in grams per cc.

The coefficient K_L varies greatly, depending upon the age of the surface film. Adeney and Becker[9] found K_L for atmospheric gases to be about 0.4 for quiet surfaces at 15° C., and calculated the film thickness to be 0.17 centimeters. By bubbling gases through water, Lewis and Whitman found the value of K_L to be about 60.0, and calculated that it corresponded to a film thickness of 0.0011 centimeters. If these computed film thicknesses are correct, then the film around a bubble rising through the water is less than 0.01 the thickness of the film on a still surface. The coefficient K_L and film thickness for several gases under varying conditions are given in Table II.

The question is, which of the values for K_L nearest approaches that of the water passing through a filter bed when it comes in contact with the air which has collected. Even after enough air has collected in the bed to equal a depth of several inches there are still places where the water will flow through without coming in contact with the entrapped air. There will be other places where it is making its way through the entrapped air in very thin films or very fine streams. The quickness with which the air is released indicates that the coefficient K_L is nearer 60.0 and 0.4, though the extreme thinness of the streams or films of water may have great influence. Assuming 40 per cent voids in the sand beds, the theoretical rate of straight downward travel at 2 gal. per square foot per minte would be approximately 0.67 ft. per minute. This is assuming no air present. With the voids three-fourths filled with air in the section where air is present, the theoretical rate would be close to 2.7 ft. per minute. It of course is evident that the rate of flow is quite variable, depending upon the resistance to the flow. With the zone of entrapped air 0.2 ft. in thickness, we can assume that there are several seconds in which the water is in contact with or in close proximity to an air surface. If the liquid surface approaches that of a falling drop, the several seconds is sufficient time for the liquid in very thin streams and films to release practically all its supersaturation. This is assuming the rate of escape of gases is about the same as the rate

TABLE II.—THE COEFFICIENT K_L FILM THICKNESS FOR VARIOUS CONDITIONS

R.P.M. of Stirrers, Etc.	Investigator	Gas	K_L	Film Thickness in Centimeters
At rest	Adeney and Becker	O_2, N_2	0.4	0.17
60	Davis	O_2	3.3	0.020
150	Becker	O_2, N_2	5.0	0.013
250	Bohr	CO_2	7.5	0.009
1,000	Becker	O_2, N_2	15.0	0.0045
Bubbles rising	Lewis and Whitman	CO_2	60.0	0.0011
Drops falling	Lewis and Whitman	CO_2	60.0	0.0011

of absorption, and there is sufficient evidence in the chemical literature to warrant such an assumption.

Factors Essential for Starting the Release of Air in Supersaturated Water.—Even though a liquid is greatly supersaturated with air it is not likely that gas bubbles will start forming within the liquid itself. In fact, so far as the writer knows it is impossible to start a bubble within a liquid. If a dry glass beaker is filled with water slightly supersaturated with air a number of air bubbles will form on the glass surface, but the beaker has been wet for several days no bubbles will form on the glass surface even though the water has considerable supersaturation of air. It is possible to produce a supersaturation in which bubbles will form on a surface that is continuously wet, as is the case of sand in a filter bed, but the supersaturation required is much greater than will likely occur in any filtration plant.

This is one of the reasons why there is very little escape of air from supersaturated water in the mixing and settling basins. If a small bubble is carried beneath the surface in settling basins where the water is supersaturated, and begins to enlarge, it quickly rises to the surface and escapes. As stated, new bubbles cannot start forming in the water. What the sand beds do is to hold the air bubbles so they will not escape into the air. The writer has shown[4] that very small bubbles require a greater supersaturation for them to increase in size than for larger bubbles by the fact that when a small air bubble and a large one are placed close together in water just slightly supersaturated with air the small bubble decreases in size by going into solution while the larger bubble increases in size. This may partially explain why a very great supersaturation is required for bubbles to start forming on a surface continuously under the water.

One thing is evident in the escape of air in sand beds, there must be some air present to start the escape. For a filter that has collected air in its previous run, all the air is not washed out and many small bubbles are left attached to the sand to start air escape as soon as the water passing through the sand becomes supersaturated due to the increase in loss of head. The curve in Fig. 3 shows that the first point of supersaturation after the water reaches the sand level is near the surface of the sand. This perhaps is where most of the bubbles which are not washed away during the washing period are concentrated. A sand grain with a bubble attached is easier to lift by the wash water and it most likely will remain at or near the surface of the sand when the sand settles back after washing. The writer has observed this very condition many times in glass tube filters. In some instances the adhering bubble is large enough to carry the sand grain away with it in the wash water.

Sand Loss Due to Air Collecting in Sand Beds.—Many may not be aware that there is considerable loss of sand in washing an air-bound filter. Every filter operator is familiar with the unsightly foam that collects on the surface of the water, but they probably do not realize how much sand it contains. The writer has made measurements of the amount of sand carried away with the foam. Table III gives the results of several tests made a few years ago.

The diameter of the sand washed away varied from 0.34 mm. to 0.94 mm. in diameter. As only one sample was measured when ferrous sulfate was used to coagulate the water, the volume of sand washed away with the foam as given in the table should not be taken as typical of this treatment. When we see the foam collect 1 to 2 in. in thickness each time a filter with air in it is washed, it is evident that the sand loss will be great within the course of a year should there be air-binding all the time.

It may seem unusual for air bubbles to adhere to sand so toughly the washing will not knock it loose. The reason for this may be that the surface film around the bubble is toughly formed due to coagulated matter filtered from the water getting into the film, and during washing some of the sand grains themselves may be forced into this film. If one will watch the washing of air-bound glass tube filters they will become aware that some of the bubbles cling to the sand quite firmly. No one need expect to see nearly every sand grain with a bubble attached. Only a very small percentage of the grains will be found with attached bubbles, but there are enough to cause some loss of sand each time the filter is washed when air has collected in it. Also there will be enough of the attached bubbles that are not washed away to furnish the necessary air surface to start the escape of air as soon after washing the filter as the water passing by the bubbles become supersaturated due to the decreased pressure as the loss of head increases.

Slight Supersaturation May Not Cause the Release of Air.—Rain water should be saturated with air and the water in most flowing streams should be nearly saturated with air all the time, yet many filtration plants taking water from running streams are not troubled very much from air-binding. A condition might be assumed that very likely is typical of a number of plants. The top of the sand is about 5 ft. below the water surface, and the water has an amount of air in it that will require 1 ft. of suction from atmospheric pressure to make it become just saturated with air. This is equivalent to 1 ft. of head. With 1 ft. initial loss of head when the filter is put into operation after washing, perhaps 6 in. of this loss can be assumed to be in the top 2 in. of sand. This will mean that the total loss of head on the filter will have to increase to about 6.5 ft. before the water just becomes saturated with air in any part of the bed. If the filter is washed at a loss of head from 8 to 8.5 ft., only about 2 ft. of suction develops at the point of maximum suction.

During the period while there is pressure on the water in the sand and the water is just saturated with air at atmospheric pressure, the water beneath the surface will be under-saturated with air and there will be a tendency for the entrapped bubbles, if there are any, to go into solution. This pressure may be sufficient in many waters to dissolve all air bubbles before the loss of head on the filters reached the point where saturation equilibrium is produced. Air bubbles incased in a film containing suspended matter do not go into solution very rapidly, and it may require fairly long filter runs to give time for such bubbles to go into solution.

Thus it might be said that the average rapid sand filter starts off with a tendency to dissolve any air bub-

TABLE III—VOLUME OF SAND IN FOAM PRODUCED BY WASHING AIR-BOUND FILTERS

Coagulant	Approximate Age of Foam Before Collecting	CC. of Sand in 2,000 CC. of Foam	Per Cent Volume of the Foam
Aluminum sulfate	6 hours	6.0	0.30
Aluminum sulfate	7 hours	8.0	0.40
Aluminum sulfate	2 minutes	2.0	0.10
Aluminum sulfate	2 minutes	3.0	0.15
Aluminum sulfate	2 hours	2.6	0.13
Ferrous sulfate	2 minutes	0.05	0.0025
Aluminum sulfate	2 minutes	0.3	0.015
Aluminum sulfate	2 hours	2.5	0.125
Aluminum sulfate	10 hours	4.5	0.225
Aluminum sulfate	2 minutes	5.5	0.275
Aluminum sulfate	2 minutes	3.0	0.15

bles that may be present either in the sand bed or the coagulated matter, and that most filters reach a point where the water is slightly supersaturated as it passes through the sand bed. The point of greatest supersaturation is near the surface of the sand. For the release of air to start, there must be some bubbles that do not entirely go into solution when the loss of head is low, or the coagulated matter must carry bubbles onto the sand.

Conclusions as to the Best Methods of Reducing Air-Binding.--For plants that are already constructed, it may not be practical to prevent air-binding at times. The filters may be washed at a lower loss of head and some of the trouble avoided, but when the runs are very short this is not always practical. If the trouble is due to air leaks in the suction of pumps, or other such causes, this may be avoided by preventing the air from getting into the water. In some instances the growth of algae in reservoirs may be lessened, which will reduce the tendency of the water to become supersaturated with oxygen. Algae probably are the cause of only a very small amount of air-binding.

It is believed that designing engineers should give more consideration to the elimination of air-binding troubles in their designs. Make the designs so there will be little or no tendency for the water to become warmer before it passes the filter beds. Also design the sand beds low enough below the water level so that there will be little or no negative head developed in the sand beds at the maximum loss of head. If it is not practical to prevent the water from reaching the filtration plant so supersaturated with air that the above precautions will not prevent the escape of air in the sand beds, most of the supersaturation may be eliminated by spraying the water into the air.

REFERENCES

[1] Ellms, J. W. Water Purification, p. 423, McGraw-Hill Book Co., 1928.

[2] Hatfield, W. D. Experience with Air-Binding of Rapid Filters. Engineering News-Record, 89: 19, 783-4, November, 1922.

[3] Fields, F. V. Remedying Air-Bound Filters. Water Works, 66: 173, May, 1927.

[4] Baylis, J. R. Influence of Curvature on Air Saturation of Water and Its Relation to the Air-Binding of Filters. Ind. & Eng. Chem., 17: 9, 974-9, September, 1925.

[5] Powell, S. T. Operation and Control of Rapid Sand Filters. Water Works, 66: 361-3, September, 1927.

[6] Caird, J. M. Air Bound Filters. J. Am. Water Works Assoc., 2: 1, 103-6, March, 1915.

[7] Whitman, W. G., and Davis, D. S. Comparative Absorption Rates for Various Gases. Ind. & Eng. Chem., 16: 12, 1233-7, December, 1924.

[8] Lewis, W. K., and Whitman, W. G. Principles of Gas Absorption. Ind. & Eng. Chem., 16: 12, 1215-20, December, 1924.

[9] Adeney, W. E., and Becker, H. G. Determination of the Rate of Solution of Atmospheric Nitrogen and Oxygen by Water. Phil. Mag., 38: 317-38, 1919.

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Experiences at Cleveland with Bacterial Aftergrowths in Distribution Systems

To the Editor: In the October issue, Vol. LXXVII, No. 10, an article appeared on "Bacterial Aftergrowths in Water Distribution Systems" by Mr. John R. Baylis, associate editor.

In this article Mr. Baylis' findings confirmed the findings of the Cleveland Water Department; that is, that due to the accumulation of sediment in the pipe mains of the distribution system, the bacterial counts and B. coli increased materially. This sediment consists chiefly of dead micro-organisms.

In the city distribution system we have one open reservoir on the raw water supply, and two open reservoirs on the filtered water supply.

Some 20 years ago it was the practice, in the summer, of opening up fire hydrants on dead ends of the system to flush out the mains. In the fall of 1911 chlorine was adopted as a sterilizing agent, and mains were still flushed out at infrequent intervals.

It has been the practice for years of the City Health Department to take half a dozen or so samples each day on the distribution system. These samples invariably showed up worse than our plant effluents. In fact twice in the last ten years I have had to install temporary chlorine equipment at the open reservoirs to kill aftergrowths.

November first last year, we installed an ammonia equipment at the Division Ave. filtration plant, and January first, this year, one at the Baldwin filtration plant. The results this year, up to date, have shown residual chlorine in the water at the extreme ends of the distribution system, no B. coli, and extremely low bacterial counts. The water leaving the plants takes approximately five days to reach the ends of the distribution system, and some of the water passes through two open reservoirs.

In answer to Mr. Baylis' article I would say, where present systems have open reservoirs, and cannot be covered very easily, the use of ammonia with chlorine is the answer to the problem. In fact, even having no open reservoirs on the system, ammonia should be used with chlorine to prevent aftergrowths so as to keep the B. coli contents as low as that produced at the plant effluent.

Without the use of ammonia, chlorine residuals cannot be maintained, and if chlorine residuals are not maintained the water supplied to the public is not kept sterile.

The above information is a resumé of our conditions here in Cleveland, and I thought would be of interest as it gives the answer to Mr. Baylis' article; that is by the use of ammonia in connection with the water supply all the troubles in the distribution system are eliminated.

W. C. LAWRENCE,
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$400,000 Greek Contract Awarded Ulen & Co.

Announcement has been made by Ulen & Co., engineers, of New York, N. Y., and Lebanon, Ind., that they had obtained from the Greek government an additional contract to build a rapid sand filter system for the new Athens water supply at a cost of about $400,000. American equipment will be used. This additional work will give to Athens one of the most modern and complete water-supply system of any city in the world, with a daily supply of over 15 m. g.

The new work in Athens supplements the work al ready accomplished by Ulen & Co. The Marathon dam, faced with the Pentelikon marble, which was used by the Athenians to build the classic structures of the Acropolis, and the hundreds of miles of pipe that have been laid, as well as the reconstruction of the aqueduct built by the Roman emperor Hadrian in 130 A. D., are some of the features of the work which has aimed at an adequate water supply, something Athens has lacked for 2,500 years.

The Works Operator's Confidant

Why the Operator of Water Works or Sewage-Works Should Keep a Diary of Plant Doings

By MORRIS M. COHN
Sanitary and Testing Engineer, City of Schenectady, N. Y.

IN the office of a great executive of an equally great utility corporation, hangs a framed plaque that asks curtly, "What Are the Facts?" In brusqueness and in directness, this query is symbolic of the times. There is a desire to know the why and wherefore of things.

Since the water purification plant and the sewage treatment plant are true representatives of the age, it is but reasonable to discover that this fact-finding tendency has invaded the field of the works operator. No subject has received more attention, been discussed more exhaustively or written about more voluminously than the subject of the necessity for the maintenance of complete records of plant operation. It has been the object of investigation by every water-works and sewage-works organization worthy of its name. Committees have convened and resolved with whereas after whereas that operation records are essential.

Printers have grown rich turning out record forms that range in size from the small sheet to charts that cover the walls of many offices. Recording guage manufacturers have developed mechanisms with floats and diaphragms and ingenious helical springs to supply the ever-increasing demand. And the operator has become weary, working into the wee hours of the morning, filling in the blank spaces and running planimeters over the face of charts made by scores of recording pens. Indication that there has grown up a record structure that is most cumbersome and un-uniform comes to us in the movement now on foot to reduce records to some more simple basis that will result in figures comparable from plant to plant.

But the records that are being accumulated in every self-respecting works are as cold and bloodless as the plaque that hangs on the office wall. They are but the skeleton of plant activity, they have no soul. There is need for a record of accomplishment that expresses the human side of this intensely human phase of municipal government. The operator of sewage-works or water-works who is not keeping a diary of plant doings is missing an opportunity to inject life into his work and to give himself a great deal of pleasure.

Keeping a good diary is becoming a lost art. Only the great and near-great keep a record of daily accomplishments. If the plant is to be great or near-great, a diary is a necessity. The definition of a diary explains its scope. A diary is defined as a register of daily occurrences and duties, a book for daily memoranda. Thus defined, the task of keeping this human record becomes easy. Sit down for a few moments at the end of the day, think a little, and jot down the things that have been done at the works during that day, the things that are not covered by the record forms or interesting angles of things that might be expressed by figures or notations alone in the tabulations. The day shift has gone home, the laboratory staff has left for the night. A sort of quiet has settled over the office. No one will pop in to ask aquestion about how to do this or when to do that. Open the little red book that you have learned to know as your friend and jot down your own thoughts. Perhaps your men found a still-birth on the bar rack this morning or you discovered the first psychoda of the season flying around near the trickling filters. It is likely that a group of college students were down on an inspection trip today. You have just reached the decision that the experimental baffle you placed in your sedimentation basin is causing too much sediment to deposit over the far corner. A neighbor dropped down today and complimented you on the fact that he has never smelled a plant odor up the street leading to the works. The local newspaper has carried a story about the beauty of your grounds. The rain of last night got you out of bed when the emergency overflow in the diversion manhole failed to function. The gas-burner, connected to the gas collectors on your sludge digestion tank, backfired and blew out the safety relief diaphragm. That hydraulic packing that the purchasing agent bought for you last week is working splendidly on your centrifugal pumps. You just had word that the estimate board has vetoed your request for additional funds for structure painting. You must look into the leak that has developed in your wash-water storage tank. Such facts as these you can confide to your diary; it will never divulge a confidence.

You will find that keeping a diary will prove of much value to you. Retrospection is most revealing. When you sit down and review the accomplishments of the day, you will have ample opportunity to discover your errors of omission or commission. The conclusion you draw about the value of a certain piece of work that took practically your entire day will, when placed in writing, lead to a decision for change of procedure or justication of your methods instead of being passed over very lightly in your mind.

You can't write a dairy without thinking and what our plants need is more thought on the part of the men who shape their policies. You will find that you become more observant of operation details that you missed before. Report-writing becomes a pleasure when you can browse through your daily notes and get into the spirit you were originally in when you actually went through the period the report will cover. Your dairy will give you opportunity to blow off steam and vent some of the inward feelings that the poor plant operator often gets no opportunity to express.

Your diary, if it becomes a semi-official document, may become a real aid to the municipality. When you leave your position to accept another, your successor will find the plant diaries a veritable fountain of information and inspiration. He may himself enter into the spirit of accomplishment that your diary emanates. The blank page may become to him a challenge to do something worth writing about. The record of personal observations may even have legal value. The statement in the writer's diary that he had cautioned his night men to use care walking on the Imhoff tanks one sleety evening, resulted in the decision of the city to settle out of court a case involving a damage caused by a slippery pavement. Another time, the statement in the writer's diary that sewage flow conditions during a midnight storm were worse than he had ever seen was included in the record of the city's defense of a sewer-flooding claim. The Venturi meter at the pumping sta-

tion gave the cold blooded flow data but the personal diary notation lent comparative values to the formal record.

You visit one sewage-works or water-works and find there an efficient installation owned by the municipality and you inquire the name of the operator. You visit another installation that seems to exude the spirit of the operator in charge. This works is in charge of a man who is living his work—it has come to be known by the man's name. Mention the name of the city and you immediately bring to mind the man who has made that sewage or water plant what it is. The first plant is but so much piping and concrete. The latter plant seems to have a soul. There is no one thing more helpful in injecting this highly desirable attribute into a plant than the maintenance of a plant diary by the operator. The diary is not the important thing. It is but that it typifies the mentality that is being brought to the job of providing pure water to the community or safeguarding the health of the neighboring municipalities down the diluting stream.

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The Economics of Utility Rate Making

The basis of value for rate making is the value as between a willing purchaser and a willing seller, Nicholas S. Hill, Jr., of New York, president of the Hackensack Water Co. of Weehawken, N. J., declared in an address on "The Economics of Rate Making" at the annual meeting last month of the Pennsylvania Water Works Association at Atlantic City, N. J.

"The true present value for rate making," Mr. Hill said, "is the same as the value for purchase and sale. Utilities have not three or four values, one for the purpose of taxation, another for rate making, and another for purchase and sale. Such an assumption is not founded on reason or supported by law."

Public utilities have a duty to perform for the public in return for which they should receive fair compensation, Mr. Hill asserted. The utilities and the public, he pointed out, have such intimate business relations that a blow at either must seriously injure the other, and, though there have been errors and confusion on the part of both, the fact that the capital invested in utilities is largely the money of the people, and not necessarily that of a group or coterie, should not be lost sight of.

"The hard earned investments of the public should in all equity be safeguarded to prevent their loss by manipulation and to insure a fair return," he added. "A clear comprehension of this mutual relationship is needed on the part of both the utilities and the public. The idea that a utility is a private business enterprise is a popular fallacy.

"The property of such a concern may be privately owned, but the use to which it is put is public. In its use the public is vitally interested. It is therefore, essential that all men should be straight thinking and stand for fair dealing as between utilities and the public which they are established to serve.

"With this concept of the relationship between utilities and the public which they serve, it is obvious that if the public expects efficient service it must allow utilities to earn an income sufficient to enable them to give good service. In order that this income may be sufficient to give good service the utility must be allowed:

"First, to earn a return sufficient to pay interest and dividends to its bond and stockholders and to have a sufficient surplus to acquire new capital from time to time as the requirements of the service make necessary.

"Second, to earn an income sufficient to cover operating and maintenance expenses, taxes and a proper annual reserve against depreciation of its property and plant.

"The economics of rate making, therefore, are based primarily upon securing an income sufficient to meet the requirements. The establishment of the fair value of the property upon which a fair return is to be estimated is but one element of the problem of determining fair income.

"The courts have generally held that the value of the property to be determined is its fair value at the time when the inquiry is made regarding the rates, and that if the property which properly enters into consideration of rates has increased in value since it was acquired the corporation owning it is entitled to the benefit of such increase.

"So far as water works are concerned, the latest decision of the Supreme Court which holds this view is in the case of McCardle vs. the Indianapolis Water Co., in which there is a clear enunciation of the principle. Many utilities are inclined to interpret this rule as meaning that the cost of reproduction new less depreciation measures value. I have never been able to find a single decision of any court making such a rule, the Indianapolis decision included.

"If the public on the one hand is expected to provide a fair return on the fair value of the used and useful property, it cannot on the other hand be expected to recoup losses resulting from errors in judgment, waste, extravagance and speculation on the part of the owners of an overbuilt property.

"However this may be, it does not justify setting up a hokus pokus reproduction estimate by eliminating items of value from the total and thereby confuse the ascertainment of true value.

"The only way true value may be reached is by reproducing the existing plant item by item as is and to reason a priori from this in what manner reproduction cost must be modified. It is highly improper and confusing to lop off portions of a plant, substitute other materials for the materials actually used, and arrive at a result which indicates nothing and gives no basis for the exercise of judgment.

"Few people recognize the close inter-relationship between value and income. To maintain a fair relationship between the owner of a property and the owner of money both must be considered, but in view of the fact that rates for money are not fixed by the state but by the law of supply and demand, the inquiry must be limited to ascertaining the fair rate of return in the contemporary money market on the fair value of the property at the time of its appraisal."

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North Dakota Water Works and Sewerage Operators to Meet in December

The second annual meeting of the North Dakota Water and Sewage Works Conference will be held at Grand Forks on Dec. 8, 9 and 10. A feature of this year's meeting will be a short school in conjunction with the School of Engineering at the State University. A short course will cover topics of special interest to water and sewage works operators as well as consulting engineers. A number of papers covering various phases of water, water supply and sewage disposal problems have also been arranged. The officers of this organization are: E. J. Thomas, Minot, president; William Yegen, Bismarck, vice-president; A. L. Bavone, Bismarck, secretary-treasurer.

Why It Rains More During the Early Morning and Late Afternoon

By HALBERT P. GILLETTE

BOOKS on meteorology have frequently called attention to a prevalent 12-hour cycle in barometric pressure that is concurrent with a similar cycle in electric potential gradients in the atmosphere. In his "Physics of the Air" Humphreys says: "It has been known now for 2.5 centuries that there are more or less regular daily variations in the barometer, culminating in two maxima and two minima during the course of 24 hours. * * * * Since Beal's discovery (1664) the same observation has been made and puzzled over at every station at which pressure records were kept and studied, but without success in finding for it any adequate physical explanation."

The reason for failure to find an explanation long ago lies in the fact that the electron was not discovered until about 30 years ago, and that the existence of a shell of electrons around the earth was not suspected until several years later. I refer to the "Heaviside layer" of electrons, which reflects radio waves.

On Sept. 12, 1930, American newspapers published abstracts of a scientific paper read the day before by Marconi in Italy, in which he advanced the theory that several distinct shells of electrons surround the earth. I had previously come to the same conclusion, and had written three articles, one of which was then in type, expounding a multiple electron shell theory. I had also given an interview to a California paper, in which I had said that "it is reasonable to suppose that, like the earth, the sun is surrounded by shells of electrons." That interview was published on the same day that Marconi's theory of multiple electron shells was first published in American newspapers. "The Foothill Review" (South Pasadena, Calif.), of Sept. 12, contains the following interview that I had given several days before.

"About two hours before sunrise the barometer usually falls slightly and two hours before sunset it repeats this process. When the barometer falls rain is most apt to occur.

"This twelve-hour period between low barometric pressures is quite like the 12-hour period between tides in the ocean. However, oceanic tides are due mainly to the moon's gravitative pull and it has been found that the moon produces almost inappreciable tides in the atmosphere. It is clear, then, that some other force than gravitation causes the fall of the barometer every twelve hours. I attribute this phenomenon to solar magnetic force.

"The earth is known to be surrounded by a shell of electrons. Electrons are particles of matter smaller than atoms and they are always charged with electricity. When in motion an electron has magnetic properties. Two electrons moving in the same direction attract one another. Two electrons moving in opposite directions repel one another.

"It is known that the sun's atmosphere contains electrons, so it is reasonable to suppose that, like the earth, the sun is surrounded by shells of electrons. What magnetic effect would a solar shell of electrons have upon a terrestrial shell of electrons?

"The answer is easy if it is remembered that both the sun and earth are rotating in the same direction, counter clockwise,around their axes.

"In consequence of this axial rotation, the electron shells in the solar and terrestrial atmosphere are also rotating, and the electrons consequently behave like magnets.

"The terrestrial electrons nearest the sun repel the solar electrons nearest the earth, because they are moving in opposite directions. On the other hand, the terrestrial electrons farthest from the sun are attracted by the solar electrons nearest the earth, because they are moving in the same direction. Consequently a terrestrial electron shell is squeezed by these two forces, and is brought nearer to the earth along the central meridian or plane that passes through the centers of the earth and the sun. This squeeze causes the electron shell to bulge out along a plane perpendicular to the central meridian. Thus we get a magnetic tidal wave in the electron shell, very similar to the gravitative wave in the ocean.

"A little consideration shows that the bulge in the electron shell would be greatest at 6 a. m. and 6 p. m. were there no friction or inertia to retard this magnetic tide. Any such resistance would cause the tidal bulge to come earlier, and as a matter of fact it comes two hours earlier.

"When an electron shell thus bulges away from the earth it lifts air with it and so reduces the pressure on the air below, causing the barometer to fall. But the lifting of the air brings it into a cooler region, which tends to precipitate some of its moisture. This explains the tendency toward greater rainfall at 4 a. m. and 4 p. m.

"After arriving at this semi-durinal explanation of barometric lows, it occurred to me that earthquakes should be more numerous about 4 a. m. and 4 p. m. I investigated some 200 quakes in Alaska and found that twenty-two per cent of the quakes occurred between 3 o'clock and 7 o'clock in the morning and twenty-four per cent between 8 and 12 p. m. In other words in one-third of the day nearly one-half the earthquakes occurred. There were 40 per cent more quakes during the hour from 4 to 5 than during the average hour.

"Thus my theory as to earthquakes was sustained by the facts, and, in addition, I found that the period of 8 to 12 p. m. is abnormally quaky. This led to an investigation of the reason why that period is so quaky, but as the reason is somewhat difficult to present without a drawing, I will not attempt to give it.

"Alaska is an exceedingly quaky region because it is so near the center of the great molten whirl that uplifted the Aleutian Islands and created that great chain of volcanoes many of which are still active. California has no volcano that has shown activity since Mount Lassen erupted in 1851."

To the foregoing interview a few allied facts may be added. In the "Monthly Weather Review," September, 1928, J. F. Voorhees published the results of his analysis of the hourly precipitation at Knoxville, Tenn., during the years 1898 to 1924, inclusive. The rainfall curves of average hourly rainfall show two maxima, one at

5 a. m. and the other at 6 p. m. The two minima are at about noon and midnight. The average hourly rain from 4 to 6 a. m. was 25 per cent in excess of the average hourly rain at midnight. The average hourly rain from 3 to 6 p. m. was about 8 per cent in excess of the average from 4 to 6 a. m., or 35 per cent in excess of that at midnight. The average hourly rain at noon was 7 per cent in excess of that at midnight. The rainfall from 6 a. m. to 6 p. m. was 51.5 per cent of the total for the 24 hrs. From these percentages it is evident that the semidiurnal barometric tide is a very important factor in rainfall in certain localities. Hence it follows that the electromagnetic forces that presumably cause this tide are very important factors in causing rainfall.

Huntington, in "Earth and Sun" and in "Climate Changes," states that while he is convinced that electricity plays a part in causing rainfall, he is equally convinced that it is a very minor part. And he points to the "march of the seasons" as evidence that the quantity of heat received by the earth at different latitudes is the major factor. But this latter argument seems defective, for rainfall is not primarily a function of temperature, else all places in the same latitude would have rainy seasons at about the same time. California's rainiest month is January, whereas that of Texas is July, when California gets almost no rain, yet they are in nearly the same latitudes. So many other similar differences exist in the world that it is clear that the "march of the seasons" as to rainfall is often quite different from the "march of the seasons" as to temperature.

While it was long ago discovered that the 12-hour cycle of barometric changes is concurrent with a 12-hour cycle in the electric potential gradient in the lower air, no adequate reason for this relationship had been suggested. An adequate reason is now supplied by the theory that the electron shells around the earth are lifted twice a day to a maximum height, like the ocean tides. This semidiurnal lifting is effected, I believe, by the electron shells that surround the sun. When a terrestrial shell of electrons bulges away from the earth, the potential gradient in the lower atmosphere should be lowered, and this is evidently what occurs.

In addition to causing increased precipitation by lifting the electron shells where clouds exist, the bulging up of those shells undoubtedly causes a flow of electrons from the earth into the air. Such a flow would increase the intensity and magnitude of the electron whirls in the atmosphere. I regard those electron whirls as the cause of cyclonic storms. Cyclonic storms tend to migrate, and thus serve to carry moist ocean air inland where some of the moisture is precipitated.

Condensation of moisture is known to be effected by electrons. Add to this the electron-whirls as a cause of cyclonic air-whirls that spiral upward; and to that add the electron shells that are caused to rise and fall periodically by solar and planetary magnetic forces, and there results an electron theory of rainfall that explains most of the enigmas of that phenomenon.

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How New Water Works Reduce Fire Insurance Rates.—The town of Hartford, Kan., installed a $40 000 water works in the spring of 1930. Fire insurance rates have now been reduced from 15 to 60 per cent on mercantile establishments and 21½ per cent on dwellings, or an average of from 25 to 30 per cent on property within the city limits, as a result.

Coagulation Conditions and Bacterial Efficiency of Preliminary Water Treatment

The United States Public Health Service has recently announced the results of certain experimental studies relating to coagulation conditions and bacterial efficiency of preliminary water treatment. The studies recorded in this report are concerned with the effects of (a) the period of sedimentation, (b) the method of applying coagulant to the raw water, (c) the hydrogen ion concentration of the coagulation reaction, and (d) the density of coagulant added to the raw water, on the bacterial efficiency of coagulation-sedimentation as a preparatory treatment of water for rapid sand filtration and, incidentally, on the efficiency of the entire process of rapid sand filtration.

The experiments were carried out during portions of the three years, 1926, 1927, and 1928, at a fully equipped experimental rapid sand water filtration plant of 160,000 gal. daily capacity, designed to typify, as nearly as possible, current large-scale practice in this process of water purification, but with certain additional features incorporated in the plant for experimental purposes.

The results of the study yielded the following main conclusions:

(1) Substantial gains in the bacterial efficiency of coagulation-sedimentation resulted from prolongation of the nominal sedimentation period up to 8 or 9 hours, and measurable gains with periods up to 12 hours.

(2) Variations in the hydrogen ion concentration in the coagulation reaction from 5.6 to 6.9 produced little effect on the efficiency of coagulation-sedimentation. The efficiency became sharply diminished, however, with hydrogen ion concentration values exceeding 7.0 and slightly improved with hydrogen ion concentration values approaching 5.5.

(3) The bacterial efficiency of double-stage coagulation, with two separate stages of sedimentation, was consistently greater than that of single-stage coagulation with one stage of sedimentation. The observations indicated, however, that with the same total amount of coagulant and the same total period of sedimentation, little if any difference was observable between the results shown by double-stage and single-stage coagulation when carried out in conjunction with two separate states of sedimentation.

(4) A fairly consistent relation was shown between the amounts of coagulant added to the raw water and the resulting bacterial efficiency, both of coagulation-sedimentation and of this state in conjunction with filtration. This relationship was found to hold irrespective of raw-water turbidity or bacterial content, though it was more apparent when the turbidity and bacterial numbers were higher. Measurable gains in efficiency were shown with increases in coagulant density ranging up to 5 grains per gallon.

The general conclusion reached from the foregoing series of experiments was that the bacterial efficiency of rapid sand filtration processes can be increased very materially by means of longer periods of sedimentation and larger amounts of coagulant than ordinarily are used in current water purification practice. The economical limit of sedimentation appears to be reached some where between 8 and 12 hours, with little gain in efficiency beyond the upper limit of time stated.

Problems of the Distribution System

Tests in and Around the Pumping Station—Flushing Dead Ends and Low Points—Suggestions for Laying Mains—Installing Service Connections

By WILLIAM J. GRAY

Engineer-Superintendent, Springfield City Water Co., Springfield, Mo.

A SUMMER of intense heat and dry weather like that of the present year, is one rarely to be forgotten on account of the problems of distribution it called forth. The range extends from the supply to the consumer, the reservoir to the house faucet. So I shall open the subject, starting at the point of delivery—the pumping station.

The first things which impress us as we enter the station are the pumps which deliver the water to the city. The question arises: Are the pumps up to their maximum efficiency? Its solution is a simple matter of calculation. Take, for example, electrically driven pumps. Let me briefly discuss the procedure of making the test.

Testing Electrically Driven Pumps.—We select a certain period of time and read the electric power meters, the Venturi meter, pressure and clear well depths simultaneously every 10 minutes during the period, which is usually 30 minutes. From the manufacturer we determine the rated efficiency of the electric motor. Applying this to the power consumed, we get the amount of power delivered to the motor, known as the input power. We then determine the output power by taking the number of gallons delivered in the period, and by applying it to the head or delivery pressure, we determine the work done. Concerting this into horsepower and then into its electrical equivalent of kilowatts and dividing this result by the input power we determine the efficiency of the pumps. In many cases we will be surprised if we have never tested the pumps. The falling off may be from 2 to 10 per cent. Evaluating the loss in dollars and cents we see the value of having pumps up to their rated efficiency.

At Springfield we had this problem on our three pumps of 3, 4 and 5 m.g. capacities. We make it a rule at our station to determine the efficiency of these pumps yearly, and when the drop in the efficiency is noted, we promptly overhaul the pumps, putting in new bearings, liners and remove a large amount of corrosion. By making the inside of the surface smooth and covering it with a rust inhibitive and waterproof paint, we developed efficiency better than we expected, slightly in advance of the manufacturer's rating made 15 years ago when the pumps were installed.

Supplying Station with Surface Water.—Another interesting problem at the station is to supply the station with service water for use in cooling the bearings, laboratory work and other purposes. Heretofore, this water was taken off the high pressure lines through pressure reducing valves. The idea came to us to take water for this use from the first stage of the pumps. On two stage pumps, the pressure in the first stage is about one-half of the finished pressure of the second stage. Over a long period this makes a considerable saving in power loss.

The next important phase at the pumping station, that is, stations which are equipped with filters, is the testing of the filters. This should be done in the early spring so that if any are found below efficiency they may be overhauled before heavy draft conditions occur.

Another important step is to test, carefully, the valves on the various lines around the station—especially the transmission lines. This is very important because of the errors which creep in for no known reasons, such as slightly closed valves, unnecessary check valves, broken stems, badly corroded gates and other troubles. This applies, also, to the supply mains coming into the station.

Preparing for Breaks.—I think one of the most important safeguards, I should almost call it the foremost, is to have on hand a good supply of the various fittings and pipe which are used in the distribution system. In a growing city, breaks of more or less serious nature are liable to occur at any time. I cite one instance.

One day in August, 1929, when the thermometer was soaring upwards and the draft on us for water was doubling normal demand, suddenly one of our transmission mains, 18 in. in diameter, was broken by a contractor's heavy grader. The caterpillar tread of the grader crushed an air valve on the main and forced it with sufficient pressure to burst open the line. This main carried about 100 lb. pressure and you can imagine the fountain display we had before it was possible to shut off the lines. In less than five hours this main was repaired and back in service. This would not have been possible had it not been for the extra pipe and fittings sufficient to make the repairs.

Importance of Maps and Records.—Here let me add a few words, before going into other problems of the distribution system about the importance and value of maps and records giving completed details of the distribution system. The importance of these is often underestimated. This is false economy, because their worth is demonstrated many times during the year. They indirectly create a deeper interest and greater intelligence of all the employees of the company. They prevent gross errors of various kinds, and offer the only real intelligent solution of providing for the growth of the future.

Flushing of Dead Ends and Low Points.—Upon reaching the point of distribution in the city, the first thought that occurs: Are we giving attention to the actual quality of water which we are furnishing the city? Is the flushing of dead ends and low points in circulating mains carried on periodically during the year, especially during summer months?

The fact that the mains are gridironed so that a complete circulation is established is no evidence there is not a collection of sediment in the low points in the lines. At such locations and also at dead ends the water becomes foul rapidly in the summer season, and bacteria will thrive inside the mains under such conditions. We do most of our flushing from fire hydrants. On 2-in. lines where there are dead-ends we invariably install, at the end, a 1-in. curb stop with a riser pipe so placed inside of a valve box for the purpose of blowing out the main whenever necessary. Many conditions of unpleasant taste can be attributed to the fouling of water in the dead-ends and low points of circulating mains.

Points on Laying Mains.—Valuable information may, at all times, be given for the laying of water mains.

The breaks on the water mains may be caused by various reasons, but it is a very safe policy to give special attention to the support of the main. Is the bottom of the trench firm and solid, sufficient to carry, uniformly, the load? On pipe of over 12-ft. lengths, we invariably support the pipe at two points when lining up the pipe for pouring joints. These points are about 3 ft. back of the bell and spicket ends of the pipe.

Under railroad crossings it is safe to provide at least a minimum of 4 ft. cover on the main. Once when the ditch is made the fill material is in continual vibration when a train passes over the tracks and during freezing conditions this becomes a frozen, solid mass extending to the depth of the frost. This entire weight strikes the remaining fill in the ditch a heavy, uniformly distributed blow, as the train crosses the ditch line. If the main is not firmly embedded there will be a tendency to dislodge it and finally cause a leak which ultimately will lead to disaster if not found and repaired.

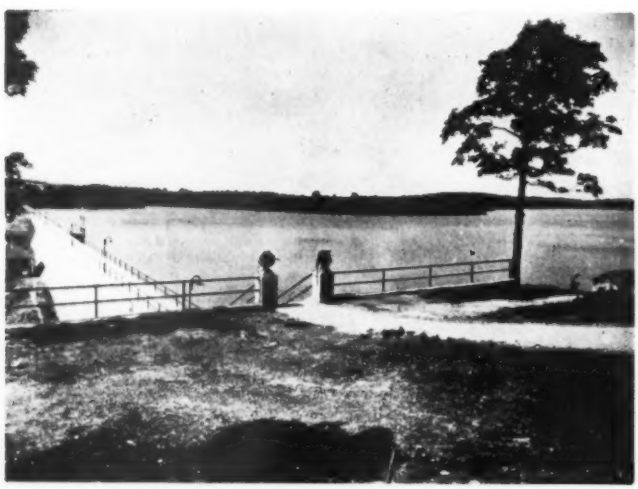
A striking example of this occurred in Springfield under one of the main lines of the Frisco railroad and if it had not been for the promptness of the water works foreman in responding to an early morning call, there would have been a wreck of a fast passenger train approaching the crossing at the time of the break in the main. Such lessons as this bring home a greater sense of responsibility on the water works superintendent and the foremen directing laying of mains.

It also should be remembered in the laying of mains where new paving is to be placed immediately afterwards that the backfill in the ditches gradually settles and throws its load on the main and also on the service, quite frequently causing a leak.

Installing Service Connections.—In this connection I might add that we tap our mains for water service on the side of the main 90 degrees from the top point.

We also put a slight bend in the goose neck, making it in a horizontal plane, this gives ample protection for expansion and contraction, thereby relieving the hazard and danger experienced on the old style, tapping of the main 45 degrees and putting the bend on the goose neck on a vertical plane.

Meter Testing, Setting and Reading.—Keeping meters in a good state of repairs is a very important step. At Springfield we test all outgoing and incoming meters. This assures us of good registration and a high degree of efficiency of the meters out in service. Fine stream management in meters is not so desirable for the coffers of the water department as is accurate measurement of large streams and the capacities of meters to permit large flows to the average consumer.



McDaniel Lake, the New Water Supply of the Springfield, Mo. Water Works Co.

The New 1,125,000,000-Gal. Water Supply of Springfield, Mo.

Setting the meter at the curb has a decided advantage. With a safe meter box which can be opened quickly it means dollars and cents to the water department.

We have meter readers in our service who have read over five hundred meters in one day with only one or two re-reads. Half of this number could not have been accomplished if the meters were in the basements. We have also found that by offering prizes to meter readers we have brought about an increase in efficiency of almost 100 per cent with a corresponding saving in cost.

Acknowledgment.—The foregoing is a paper presented Oct. 23 at the 6th annual Missouri Water and Sewerage Conference.

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Tank Manufacturer Sponsors Competition for Best Elevated Tank Design

The Chicago Bridge & Iron Works, manufacturers of steel tanks and steel plate work, is sponsoring a competition for improved design in elevated steel tanks. Four thousand dollars in prizes are being offered for the best eight renderings, divided as follows:

First Prize	$2,000.00
Second Prize	1,000.00
Third Prize	500.00
And 5 Honorable Mention Prizes of, each	100.00

Entries in the competition will consist of two drawings of a typical elevated steel tank with a nominal capacity of 200,000 gal., a height to top of approximately 110 ft., a height to bottom of not less than 85 ft., and a riser not less than 5 ft. in diameter.

One drawing will include a direct elevation and two horizontal sections or plans ¼-in. scale. The other will be a perspective drawing to the same scale.

The entries will be received anonymously, displayed in a suitable room in an impartial manner and judged by a jury of award consisting of Mr. Howard Cheney, president of the Chicago Chapter of the A. I. A., Mr. R. W. Zimmerman, architect of Chicago, and Mr. George T. Horton, president of the Chicago Bridge & Iron Works.

Mr. Albert M. Saxe of 430 North Michigan Ave., Chicago, Ill., has been appointed professional advisor for the competition and will handle all communications regarding it. A brochure giving complete details of the competition may be secured by addressing Mr. Saxe.

This competition is open to architects, engineers and draughtsmen all over the world. Applications for entry will be received by the professional advisor (Mr. Albert M. Saxe) until Dec. 1, 1930. The contest closes on March 1, 1931.

Foaming in Imhoff Tanks

Stages Involved in Digestion—Causes of Foaming—Preventive Methods—Corrective Methods —Experiences in Prevention of Foaming

By GEORGE S. RUSSELL
Russell & Axon, Consulting Engineers, St. Louis, Mo.

THE phenomenon known as foaming in Imhoff tanks has been and still is a matter for considerable study and investigation. There is no uniformity in Imhoff tank operating conditions. At different sewage works the composition of the sewage varies widely and even at the same plant there may be seasonal, daily and even hourly variations. Methods for reduction of foaming employed in one digestion chamber failed when applied to another handling the same sewage under presumably the same conditions. It is evident then that there are so many contributing factors and the processes involved are so complex that the determination of basic causes is difficult and there is great need for further study. At the present time we have to be content with stating certain causes which seem to promote or accentuate foaming without definitely knowing the fundamental cause.

Stages Involved in Digestion.—Rudolfs has suggested that the stages involved in the process of digestion be grouped for practical purposes as follows:

1. A period of intensive acid production during the decomposition of the soluble carbon compounds and the breaking down of cellulose. Organic acids are formed at a greater rate than they are broken down, resulting in a low pH and a large amount of carbon dioxide being produced.

2. A period of acid regression and acid digestion when the organic acids are decomposed at a greater rate than they are formed and the accumulative material decreases. The pH approximates neutrality during this period.

3. The period of intensive digestion of more resistent materials during which time biological balance is being established. A greater production of methans and a pH above neutrality characterizes this stage.

Causes of Foaming.—If the processes of digestion do not proceed beyond the first stage, foaming may result and the sludge will be poorly digested.

It has been stated by Chester Cohen that "Foaming conditions are largely due to abnormal physico-chemical conditions of the material in the gas vents in combination with the quantity and quality of gas resulting from certain predominating types of biological organisms or bacteria and possibly both."

With regard to the necessity for quick contact of the new sludge entering the digestion chamber through the slot in the sedimentation compartment with the old ripened sludge, it may be stated that hours of delay at this stage may be reckoned as days so far as the retarding of the digestion process is concerned. This is because the rapid production of organic acids in the first stage of digestion, as outlined above, produces inhibiting effects which bring the whole process to a temporary halt unless the acid is neutralized by either mixing the new organic deposits from the sedimentation chamber with the old alkaline sludge or by mixing chemicals such as lime to these organic solids in order to raise the pH value.

It is our belief that the rising gas filled scum requires a certain minimum of surface area in order to release its gas and that this area is not sufficient in the ordinary types of Imhoff tanks, hence the raw sludge settling through the slot is held up by this gas-filled scum which rises from below and does not come directly in contact with the digested sludge at the bottom. This action tends to keep this new sludge in the first stage and this is the basic cause of foaming.

The fact that sludge in the first stage of digestion needs to be mixed with old alkaline sludge in order that the processes of digestion may not be retarded explans why foaming is prevalent during the ripening process when an Imhoff tank is first put into operation or after shut down of the plant for repairs, and the rapid production of acid in this first stage has given rise to the statement that foaming is due to acidity. When a tank is first put into operation or after a shut down for repairs, because there is no ripened sludge to raise the pH value, lime should be added for this purpose in order to carry the digestion process beyond the first stage. Where the tank has been in operation for some time, some method of reducing the flow of gas or mixing the contents is necessary so that the alkaline ripened sludge may be brought into contact with the newer sludge in the first stage of digestion. By doing this the inhibiting effects of the rapid production of organic acids in the first stage will not bring the process of digestion to a temporary halt.

Too violent boiling or foaming is not likely to occur when the area for the escape of gas has been made large and the gas is not confined. It might be pointed out here in this connection that well digested sludge rapidly loses its inoculating capacity so that large quantities of old, well digested sludge may actually contribute to foaming when a tank is placed in operation after being out of service for a few months and the ripened sludge has been left in the digestion compartment with the idea of eliminating the troubles incident to breaking in a new tank. It may also be seen that too frequent drawings of sludge, particularly when the amount of well digested sludge left in the tank is not in sufficient proportion to neutralize the effect of the freshly deposited sludge, may give the same results as outlined above.

Preventive Methods.—The idea prevalent in small municipalities that an Imhoff tank operates automatically is a fallacy. Satisfactory operation requires intelligent and competent supervision. The operator should at least have a definite understanding of the purposes of the tank and the fundamental principles involved, and be conscientious in carrying out these purposes and principles. Even well designed and properly operated tanks may at times present difficulties which will tax the ingenuity of the most skillful operator, but a poorly designed tank may be made to give fairly satisfactory results by intelligent operation, and conversely, a well designed tank may utterly fail to produce satisfactory results if improperly handled.

In order to prevent the formation of scum in the sedimentation compartment, squeegees should be used upon the sloping baffles so as to remove all solid ma-

terials which may adhere. It is absolutely essential that these baffles and the slot below them shall be kept clean so that septic action does not occur in the sedimentation compartment. This may be necessary as often as once or twice a week. Material floating on the surface of the sedimentation chamber should, of course, be removed from the tank or deposited in the digestion chamber through the gas vents. No sludge should be removed except for the talking of samples until the tank is well ripened. It is well to provide for reversal of flow in Imhoff tanks so that the solids may be more evenly distributed throughout the digestion compartment. This is especially true in long tanks. The ripening of the sludge can be determined by examination, and under no circumstances should all of the sludge be removed at any time except during a severe case of foaming. Any accumulation of scum in the gas vents should be broken up and pushed down into the digestion chamber. If it is possible this is best done with the stream from a fire hose which may draw sewage pumped from the digestion tank itself.

When the raw sewage shows considerable acidity for short periods, it may be advisable to circulate the sludge in the digestion chamber by pumping from the bottom of this compartment and discharging this ripened sludge into the gas vents.

Corrective Methods.—A removal of some of the ripened sludge may reduce or stop the foaming. If the tank has recently been put into operation, the addition of lime to the digestion compartment may prove satisfactory. At this stage the amount of lime necessary can be found by taking a sample of the sludge liquor and titrating to a pH value of 7.0 and from this data, knowing the total volume of sludge liquor, the amount of hydrated lime necessary to neutralize it can be calculated. When a large quantity of sludge is in the tank, the quantities of lime necessary to produce satisfactory results is prohibitive.

Where the addition of lime has had little result in the correction of foaming, it has been found that although the pH value is raised shortly after this addition, it drops again rather rapidly and in a short time it is back below the neutral value again.

In our opinion the best method of addition of lime is by the use of some simple feed apparatus depositing the lime into a trough and by pumping sludge from the bottom of the tank into this trough and emptying the mixture into the gas vents. In a few cases, however, the addition of lime has been found to actually increase the foaming and it may be necessary to draw off all the sludge and start the tank anew adding lime in small quantities and at frequent intervals in order to keep the pH value above the neutral point.

Experiences in Prevention of Foaming.—In Flint, Mich., experiments seemed to indicate that a small amount of sludge circulation by air is helpful in promoting balanced digestion, principally by preventing heavy scum formation. Our observation, as indicated previously in this article, is that any type of recirculation by breaking up the sludge and the freeing of gas may serve to keep foaming under control by rapidly bringing the sludge to a more balanced state.

In Austin, Tex., it was fairly well established that relatively small chlorine dosages (6 p.p.m.) applied to the sewage entering the tank reduced the tendency to foam and produced a more satisfactory tank affluent. Dosages as low as 3 p.p m. reduced the foaming noticeably. It was noticed that if odor control was not a factor the dosage of 3 p.p.m. might be concentrated over the period from 8:00 A. M. to 5:00 P. M. with approximately the same results as if applied throughout the 24 hour period.

In Germany, there has been developed a new type of tank with a submerged sedimentation compartment. This type of tank by bringing the level of the sewage in the digestion chamber above the top of the sedimentation compartment, increases the scum area and makes easier the release of gas. The tank has a sloping roof on the sedimentation section with a slot at the top so as to allow the escape of floating solids. Experiences, during the last few years, seem to indicate that foaming does not occur in this type of tank.

Conclusions.—The successful operation of the latter type of tank would seem to indicate that the prevention of foaming as outlined in this article is based on the provision of enough scum area to provide for the escape of gas. This is also borne out by our observations which indicate that foaming is most prevalent where tanks are designed with a small proportion of scum area which is particularly indicated in tanks of the multiple type where chimneys are used for gas vents. While, as has been indicated, it would seem that we cannot arrive at definite conclusions at the present time, we deem it advisable that future designs show an increased scum area, and that, in tanks already constructed, this deficiency may be to some extent provided for by corrective measures which tend to release the accumulations of gas as quickly as possible and to bring in contact the raw acid sludge with the ripened digested sludge so that the digestive process may not be interfered with but carried to their ultimate conclusion.

Acknowledgment.—The above is a paper presented Oct. 24 at the 6th annual Missouri Water and Sewerage Conference.

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Annual Convention North Carolina Water Works and Sewage Works Associations

The 10th annual convention of the North Carolina Section, American Water Works Association and the 8th annual meeting of the North Carolina Sewage Works Association were held jointly at the Skyland Hotel, Hendersonville, N. C., on Oct. 13, 14 and 15. Sixteen states of the south, east and middle west, and one foreign country were represented at the meeting. The registration reached 236, of whom 131 were city officials, superintendents, plant operators, engineers and public health officials actively engaged in the planning, design, construction, operation and financing of water and sewage works; 61 were commercial representatives of manufacturers and dealers in water works and sewerage equipment and supplies; nine were special representatives of professional journals and the press; and 35 were ladies and other visitors. The exhibits of about 30 firms were attractively arranged in the lobby and adjoining rooms of the hotel, and, as usual, constituted one of the most attractive features of the convention.

At the joint business meeting of the two associations Greensboro was selected as the next convention city, and the dates fixed as Nov. 2, 3 and 4, 1931. The officers elected for the coming year are as follows:

President, A. S. Lyon, Rocky Mount, N. C.; vice-president, Geo. S. Moore, Albemarle, N. C.; secretary-treasurer, H. G. Baity, Chapel Hill, N. C.; editor, E. G. McConnell, Charlotte, N. C.; representative on board of directors, American Water Works Association, W. E. Vest, Charlotte, N. C.; representatives on board of control, Federation of Sewage Works Associations, H. E. Miller, Raleigh, N. C., and W. M. Piatt, Durham, N. C.; chairman of nominating committee, J. O. Craig, Salisbury, N. C.

Stand-by Charges for Water Works

What Has Been Accomplished in Arriving at the Cost of and Fixing a Charge for Fire Service Furnished to Municipalities

By C. E. THATCHER

Manager of Commercial Department, East Bay Municipal Utility District, Oakland, Calif.

THE subject of this paper will first be defined. The term, "Stand-by Charges for Water Works," shall be understood to mean a charge for "readiness to serve" or "stand-by" service available to municipalities for fire purposes.

Fire Purpose Supply a Distinct Service.—If the operation of a water works was confined only to the rendering of service to domestic and industrial consumers, the transmission and distribution mains and other equipment required for such service would be smaller in size than that required to provide additional service to municipalities for fire purposes. It seems reasonable to assume, then, that anyone familiar with water works operation can and should appreciate the fact that in providing equipment sufficient in size to render additional service to a municipality for fire purposes is the rendering of a service that should be classed as distinct and separate from other services and the cost and charge for such should not be combined with the cost and charge for any other service. Those who receive the benefit of the service should pay for it. The cost of this special service is, it is thought, a just and proper charge against the municipalities.

A municipality is supported by its tax payers. Therefore, the tax payers should pay for this "readiness to serve" or "stand-by" service. For example: The tenant in a rented house should only pay for the cost of water served to him for domestic use. The owner of the house, the tax payer, should pay the municipality for the protection given to the house against fire. Further, the large area in cities upon which stands immense buildings and other structures must have fire protection. To afford such protection requires the installation by water works of facilities greater in size than would ordinarily be installed for domestic and industrial use only. It follows then that the municipality should pay the water utility for the additional service that it is asked to provide and secure the amount required to pay for such service by a tax levy. The regular consumers of water should be relieved of the burden of paying the cost of this class of service.

Difficult to Distribute Burden Equitably.—It should be appreciated how difficult it is to distribute equitably the burden of the cost of water served to each class of consumers. There appears to be no recognized authority on distribution of fire service cost. It is an innovation in cost of service distribution and rate making, in water works management, that can be classed as new. Whenever anything new is introduced for use, either a service or a commodity, someone or some agency has to carry on the experimental work and do the pioneering.

A few years ago the Railroad Commission of the State of Wisconsin came to the front and strongly advocated the establishing of a charge against municipalities for the fire service facilities and classed such as a "readiness to serve" or "stand-by" service. Naturally, the proposal of such a classification of service and the fixing of a charge covering the cost thereof met with strenuous opposition by those (the municipalities) who were suddenly called upon to shoulder the burden of the cost. The opposition cry was "You are trying to rob Peter to save Paul." It was further contended that the ordinary user of water was, as a rule, the tax payer and should stand the burden. Then, too, the making of a tax levy would upset the tax program and interfere in many localities with the tax rate limit. The commission assumed a firm stand and the records show that many decisions rendered provide for a charge against the municipalities for fire service facilities.

Wisconsin Charge for Fire Service Facilities.—By referring to these decisions it will be found that the amount derived from the charge fixed for fire service averages 33 per cent of the gross revenue of the water utility. This would indicate that the Wisconsin Commission places a high value upon such service and were quick to apportion a cost accordingly against those receiving the benefit of the service. Other public utility commissions have, in fixing rates for water works, allowed a charge for fire service facilities. The charge though, in nearly every case, yields a lower percentage of gross revenue than does the Wisconsin Commission's charge.

A California Decision.—In California it is found that the California State Railroad Commission had before it a few years back the problem of fixing a charge against municipalities for fire service. This commission stated:

"In order to furnish adequate protection against fire it is necessary to install facilities of greater capacity than are required to supply ordinary industrial and domestic demands. Such protection is a direct benefit to the community and the excess capacity of the water system which may be deemed justified by the necessity of providing for such emergency demands cannot fairly be charged against regular consumers and paid for under cover of an increase in the unit rates for water consumed for industrial or domestic purposes."

In providing for a charge against municipalities for fire service, in one of its decisions, the California Commission referred to it as "Public Use Charge." The commission apparently resorted to the enforcement of this charge upon municipalities to avoid increasing the rate for domestic and industrial service, as the water utility asked for a higher rate. The charge fixed by the California Commission for fire service in this particular case was evidently intended to be sufficient only to yield the water utility the revenue it was entitled to. The charge fixed for fire service in this case resulted in being a trifle over 7 per cent of the water utility's gross revenue.

The California Commission has on numerous occasions made known to municipalities and apparently in no uncertain terms, its attitude regarding the fixing of a charge against municipalities for fire service.

This commission stated in one of its decisions, ". . . . these municipalities must expect that at the appropriate time, when they are in a position to pay these increased charges, the rates of (name of the utility) will be revised with a view to lifting this burden from general consumers and placing it where it belongs, upon the municipalities."

Application to Municipal Water Works.—So far reference has been made only to what privately owned water works have accomplished in fixing a charge for providing fire service facilities for municipalities (the general public). Why cannot city owned water works fix a charge for similar service and relieve the general consumer of the burden of the cost? Why should the water department in a city furnish free service to the fire department at the expense of the domestic and industrial water consumers?

All cities maintain a fire department equipped with modern fire fighting apparatus and the necessary man power to operate it. Are not the fire service facilities provided by the city owned water works for the exclusive use of the fire department and constructed of sufficient size to render an adequate service in case of fire? Would it not be fair then to relieve the general consumer of the burden of the cost and include it in the fire department budget and tax levy? This method if adopted would result in having those (the general public) who receive the benefit of fire protection pay for it. In reviewing some of the audit reports of city owned water works there appears to be no set-up for such a charge. The city of Los Angeles does in its income statement show the value of some of the water service the city receives free. The value of such free service is shown as part of gross operating revenue and is finally deducted from net income. Merely a bookkeeping transaction.

How East Bay Municipal Utilities District Handles Question.—It is thought that it will be of interest to refer to the charge made by one publicity owned water works in California, the East Bay Municipal Utility District, for providing fire service facilities to municipalities. The Utility District occupies rather a unique position regarding the fixing of rates and charges for the various classes of service it renders. Within its boundary line, on the continental side of San Francisco Bay, are nine municipalities. The district is not city owned. The municipalities are, in fact, the district's customers. Each municipality pays to the district a "readiness to serve" or "stand-by" service charge for providing facilities available for fire service. The amount of revenue derived from the charge for this service is approximately 7 per cent of the total gross revenue of the district. The charge is much less than what it should be, considering the value of the service rendered.

What has been stated herein is intended merely as an exposition of what has been accomplished by the management of water works and rate making bodies, in arriving at the cost of and fixing a charge for, fire service furnished to municipalities. It is quite evident that much progress has been made. The trend is and as it rightfully should be, in water works operation, to relieve the ordinary user of water of all costs that are chargeable to other classes of service. Practically 90 per cent of water works consumers are the home and industrial users, and the service rendered to this class is charged for according to the measured volume of water used. Consumers of this class then should not be required to pay any more than the cost of the particular kind of service they receive. The fixing of a charge by water works for "readiness to serve" or "stand-by" service rendered the general public in municipalities for fire purposes will, if made effective, reduce considerably the present cost of service rendered to other classes of consumers.

Acknowledgment.—The above is an abstract of a paper presented at the recent meeting of the California Section of the American Water Works Association.

6th Annual Meeting of the Missouri Water and Sewerage Conference

Problems on the design and operation of municipal water works and sewerage systems were taken up in detail at the Sixth Annual Meeting of the Missouri Water and Sewerage Conference held in Columbia, Mo., Oct. 23-24-25, 1930. Many interesting papers were read and discussed during the meetings. The registration was larger than ever before, 92 persons having registered before the close of the meeting.

The following speakers from out of the state aided in the success of the meeting: J. R. Baylis of Chicago, A. E. Gorman of Newark, N. J., L. H. Enslow of New York, and H. B. Crane of Chicago. The other speakers were well known Missouri men in the water works or sewage treatment field. The conference is particularly indebted to Dean McCaustland of the College of Engineering, University of Missouri, and his faculty who gave valuable assistance on the program.

The conference members were served a luncheon at the Columbia City Water and Light Plant by the city of Columbia, following an inspection of the plant on Thursday, Oct. 23.

The annual banquet was held on the evening of Oct. 24. Dr. James Stewart, State Health Commissioner, was the toastmaster. Doctor Allen, Dean of the Medical School of the University of Missouri, gave a very interesting talk on the evolution of the heart. Other speakers were H. A. Buehler, State Geologist, E. J. McCaustland, Dean of the College of Engineering, University of Missouri, and Hon. W. J. Hetzler, Mayor of Columbia. Music for the dinner was furnished by the School of Fine Arts of the University of Missouri. Following the after dinner talks, much hilarity was occasioned by J. A. Strang's "Rogues' Gallery."

The papers were grouped under three headings as follows: First, papers of general interest, which included such subjects as pumping machinery, distribution system problems, corrosion of mains and other matters which did not pertain directly to the operating problems of those present but contained interesting and useful information to men in the water works and sewage treatment field. Second, papers on water purification problems, which were concerned with preparing water for filtration, filter plant operation problems, and the importance of the chemical and bacteriological laboratories in water purification. Third, papers on sewage treatment, which had to do with sewage pumping stations, foaming of Imhoff tanks, activated sludge process for small cities, and conditions necessary to successful sewage treatment plant operation.

Following the reading of papers Saturday morning, a short business session was held before adjournment. Those present at this meeting were in favor of continuing to hold the annual meeting of the conference in different cities as in the past in preference to locating permanently in one city. Also, the annual water and sewage operators school held under the auspices of the State Board of Health and the Engineering School of the University of Missouri was highly commended and all were in favor of continuing this yearly school.

The following officers were elected for the coming year: Chairman, J. N. Wells, Supt., Joplin Water Works, Joplin; Vice-Chairman, E. E. Wolfe, City Chemist, Hannibal; Secretary-Treasurer, H. D. Peters, Assistant Public Health Engineer, State Board of Health, Jefferson City.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Meeting of the North Carolina Sewage Works Association

At the joint meeting of the North Carolina Section of The American Water Works Association and the North Carolina Sewage Works Association at Hendersonville, N. C., on Oct. 13, 14 and 15, two entire sections were devoted to the subjects of sewage and sewage disposal. The attendance was over 180 and included representatives from the New England states to Florida.

The wide interest in sewage works matters in the state of North Carolina as indicated by the attendance from far points was amply justified by the revelation of progress in the art made in that state. A post convention tour of the plants of the state shows that the municipal representatives working in a remarkably intimate cooperation with the engineers of the state department of health are not only applying every scientific development of the art, in both design and operation, but are giving abundance of thought and effort to beauty and appearance. It is indeed a far cry from the weed covered sand or contact beds of a decade ago to the compact, mechanical and almost palatial equipment and housing to be found in these most modern North Carolina plants. The state is exceedingly fortunate that its demands for sewage treatment have developed since the passing of the dark ages and it has no old plants to revamp and no bad precedents to misguide it. Most of all, however, it is fortunate in the cooperative spirit which is everywhere in evidence.

As to the papers read at the meeting, Mr. G. F. Catlette, principal assistant engineer of the state department of health read one on Sewage Flows reporting the painstaking gauging of flows on all the important sewer systems of the state. From these there was produced a curve for "normal hourly variation in flow." Variations from this normal were shown to be surprisingly slight. The form of the curve was almost constant moving slightly forward or back as the outfall was short or long. The most notable variation outside of that caused by industrial waste was in the case of two college towns in both of which the high rate of flow of the afternoon was carried over until midnight instead of falling rapidly after 6 p. m.

The most impressive part of the paper was the production of rate of flow curves for days without rain as compared with the normal curves. Not only did these show that rain is responsible for a large part of the total flow, but more important from design, construction and operating standpoints, is the fact that rain is responsible for the high peaks in the curve to a suprisingly large extent.

In practically every case where a curve was produced for hourly flows for dry periods only, there was no sharp peak but a uniform flow over a period of several hours at a point perhaps 20 per cent below the "normal" peak.

The importance of the suppression of these peaks is well known to every operator whose efficiencies are upset by an hour or so of extra high flow and to every experienced designer who realizes that the nearer the flow can be kept to a straight line the nearer we can get to that ideal plant for which we hope but not too confidently.

The next paper was by John R. Downes, supervising engineer of the Plainfields Joint Sewage Works, on The Separation, Treatment and Disposal of Sewage Solids. This paper emphasized the effect of the efficiency of sedimentation on the digestion of the resulting sludge as well as the effect of grit chambers on the density of the resulting ripe sludge. It also went into the relative importance of sludge drying capacity and sludge digestion capacity and their interrelation.

The paper showed that sludge density, as such, is not as important in ripe sludge as has sometimes been considered.

A series of sludges of varying densities was prepared by diluting a sludge of 7.8 per cent solids with one of 2 per cent solids, both sludges being of the same quality and obtained from different levels of the same digestion tank. When these dilutions were observed side by side in tall glass cylinders, 4 in. in diameter, it was found that the water separated much more quickly from the thinner sludge and that the ultimate separation in inches of water separated from a 9 in. column of sludge, was inversely proportional to the densities.

This liquid was shown to represent that removed from drying sludge by actual drainage while any addition liquid removed must be by the slow process of evaporation.

Experience indicates that a thickness of 4 in. of sludge (after this initial dewatering), will dry very rapidly while depths over 6 in. will dry very slowly.

Applying a chart for the dewatering of sludges of varying densities and a curve for the time required to dry by evaporation different depths of dewatered sludge, a table was produced showing the total time required for drying different density sludges at different depths.

While an 8 per cent sludge contains twice as much solids by weight as a 4 per cent sludge it will take 2½ times as long to dry if both are applied 8 in. deep; 3 times as long if applied 9 in. deep and 4 times as long if applied 10 in. deep.

Good judgment on the part of the operator is required to get the most out of his sludge beds.

Mr. C. C. Hommon, superintendent of the Canton, O., Sewage Works gave a paper on "Utilization of Imhoff Tank Sludge for Farm Fertilizer." Imhoff tank sludge at Canton is pumped to the top of a high point of land on the city farm and from there is run by

means of ditches and furrows to the point of utilization in fertilizing crops.

Three laborers control the distribution of sludge and attend to the farming. The greatest difficulty of controlling the sludge is on very steep slopes that are bare. Vegetation, ice or snow aid greatly in distributing of the sludge evenly. Plowing is very helpful in this distribution not only because the broken land surface helps to divert the flow and spread it but because the plowed land absorbs the moisture rapidly.

Wheat fields flooded after seeding show good growth. Corn so sludged during the past dry season showed wonderful improvement. The sludge is particularly good for grass; but should be used sparringly on oats which tend to grow long, slender, weak stalks which blow down easily. Sludge is not a complete fertilizer for all crops, for instance lime should be added for clover. Indications are that land will require resludging every four years.

A neighboring farmer has installed a pump to reach parts of his farm which cannot be reached directly by the city installation. Adjoining farmers are so well satisfied that they are demanding more sludge. Other farmers further away are pooling their interests to buy pumping equipment.

Bad sludge which is difficult to dry on drying beds is readily disposed of without nuisance by the direct land fertilization method described.

Sludge of high solid content has no advantage in this system and in fact has to be diluted, if too high, to lessen friction.

Costs of this system are certainly no higher and perhaps a little lower than for drying on beds; while the matter of investment is all in favor of direct cropping, and the income from crops readily pays the interest.

Discussion of the above paper brought out the fact

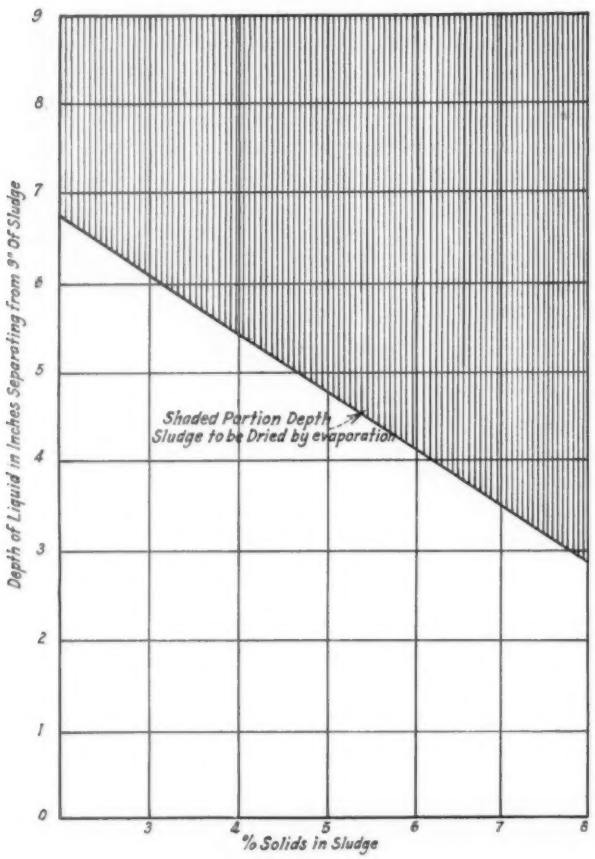

Chart 1

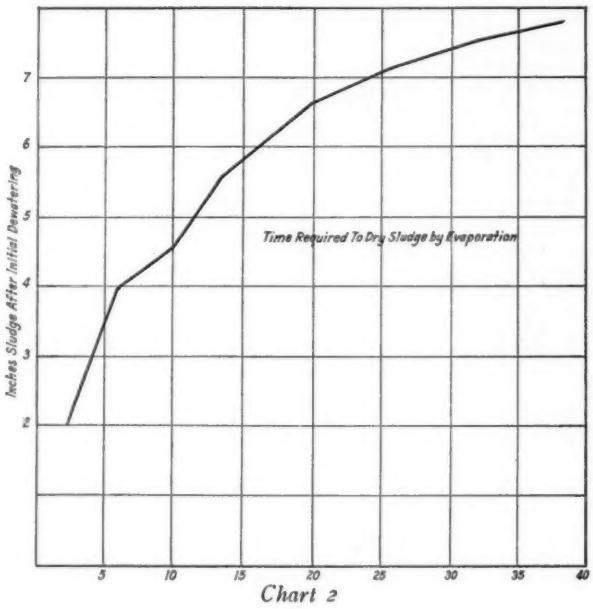

Chart 2

that at Highpoint, N. C., the disposal works are near the city prison farm of 200 acres and the 30 prisoners are used to work the farm using sludge as fertilizer. The plan has not yet been in operation long enough to give reliable results.

At Charlotte where activated sludge is dried directly on Oliver filters and loaded from the belt conveyor into farm wagons it was said that the farmers were not sufficiently attracted by the fertilizer value to keep the sludge away although it was given to them free. Wet weather caused odor troubles with the cake in the case of this activated sludge.

Mr. Roy Lamphere, supervising chemist, sewer department, Worcester, Mass., presented a paper on "Treatment of Sewage Containing Industrial Wastes."

Control of discharge of industrial wastes is very important. Such control can usually be obtained only by cooperation. Precedent in such matters is of the greatest importance. Grasp and hold control from the first. Any relaxation, however small, will result in forfeit of all power.

As illustrating the importance of industry Worcester industries give employment to 35,000 persons with a monthly pay roll of $5,000,000 and have a $190,000,000 investment. Foundry sand is one of the wastes which Mr. Lamphere suggests be intercepted at the source. At Worcester, grease is diverted to the last two tanks by skimmers so that it may be concentrated in one place. It is skimmed off at intervals and burned resulting in local odors for short periods of time.

Lime wastes from tanneries is the source of much odor trouble. Lime wastes plus iron wastes are the sources of the greatest operating difficulties at Worcester.

The quantity of industrial wastes at Worcester may be judged by the fact that normally from 1,500,000 to 2,000,000 gal. of sludge is produced per month. On account of the present business depression this volume had dropped to 1,333,000 gal. in July and to 500,000 gal. in August.

The lime and iron wastes do not interfere seriously with sludge digestion. pH of fresh sludge is 6.6 and that of digested 6.8 to 6.9.

While the settling tank effluent contains from 25 to 50 p.p.m. of iron no abnormal clogging has been noted in the filters. Reduction in the quantities of lime and

iron result in increase in nitrification in the sprinkling filters.

No permanent depreciation of plant traceable to trade wastes has been noted.

Dr. A. J. Fischer, sanitary development engineer, Dorr Co., told of activated sludge digestion at Salem, O.

Plant was designed for 1.5 m.g.d. from 15,000 persons; present flow 1 m.g.d. from 7,000 persons.

Plant consists of bar screen 1¼ in. openings; grit chamber, clarifiers, spiral flow aeration tanks, sludge digester and sludge storage tank. The old filter beds are used for sludge drying and handling storm water flows over 1.5 m.g.d. A chlorine contact basin is at present being used for tertiary sedimentation.

Mr. Fischer's summary states that the experience at Salem shows that activated sludge can be digested in separate digestion tanks. The greatest difficulty encountered was in securing a relatively clear digester overflow. This was overcome by wasting the activated sludge to the primary clarifiers at a very low and constant rate, concentrating the raw-activated sludge mixture and pumping to the digester for short periods at frequent intervals.

The above method of operation gave an overflow containing 0.25 per cent solids (as against 2.0 per cent by other methods), cut down heat losses and produced a thicker digested sludge.

Fifty and six tenths per cent of the total solids or 78.0 per cent of the volatile matter added were digested.

Gas production average 8.22 cu. ft. per pound of volatile matter added and 10.5 cu. ft. per pound of volatile destroyed.

Raw sludge pumped daily averaged 9.47 per cent solids, 35.3 per cent ash; while digested sludge contained 10.47 per cent solids with 58.1 per cent ash.

The Drying of Sludge on Sand Beds

The matter of the relative importance of drainage and of evaporation in the drying of sludge has been one for discussion over a number of years. A combination of experience and experiment indicate to the writer that the relative importance of the two will be governed by the denseness of the sludge and by weather conditions during the first 48 hours of exposure.

The process of drying is divided into two distinct parts: First, the initial dewatering which may remove from practically zero to 66 per cent of the moisture according to the quality of the sludge and its moisture content; second, evaporation.

With a good quality of sludge initial separation of liquid is negligible if the solid content is about 10 per cent and may amount to as much as 66 per cent if the solid content is but 2 per cent.

This initial dewatering may be accomplished in 6 hours in the case of the 2 per cent sludge but will require 48 hours in the case of an 8 per cent sludge.

It is during this initial dewatering period that the effect of rain on the sludge is so devasting; sometimes prolonging the total drying period from a matter of days to one of weeks.

The second part of the drying process, evaporation, depends on climatic conditions but given like conditions a layer of sludge less than 4 in. thick will dry in a few days, whereas if the layer (after the initial dewatering) is over 6 in. thick the drying will be very slow.

Chart 1 (page 396) indicates the proportion of liquid shown by experiment to separate from sludges of different solid contents.

Chart 2 indicates the time observed to be required for the drying by evaporation of different thicknesses of sludge (after the initial dewatering period).

By the use of Chart 1 followed by the use of Chart 2 the following table has been prepared to show the length of time required to dry sludges of different solids contents when applied at depths of 8, 9 and 10 in. to sand beds under favorable conditions.

Per Cent Solids in Sludge	8 In.	9 In.	10 In.
4	5½ days	6 days	6 days
5	6½ days	8½ days	10 days
6	9 days	12 days	13 days
7	12 days	14 days	16 days
8	14 days	18 days	23 days

These depths of sludge have been chosen for example as being within the usual practical range. Much good judgment may be used by the operator in determining the best depth of sludge to be applied taking into consideration weather conditions, etc., as also the convenience of removing the dried sludge frequently in thin dry cakes or at less frequent intervals in a heavier cake.

▼

Financing Sewage Disposal

Connecticut, according to Ohio Health News, seems to have about reached the point where it is ready to follow Ohio's example in establishing the status of sewage treatment and disposal as an essential public utility, to be paid for in the same manner as water supplies are paid for. The success of the system in Ohio, although it by no means has been generally put in force by Ohio municipalities, has thoroughly demonstrated its value at every angle, and to those familiar with its operation, it already is beginning to seem strange that it has not been more generally adopted outside the state. The statute under which this method of financing sewage treatment is developing, known as the "Sewer Rental Law," was enacted by the General Assembly of 1923. Nineteen municipalities are operating under it, and several others are considering its adoption.

According to a recent statement by Sanford H. Wadhams, director of the Connecticut Water Commission, nearly five years of experience with the Connecticut law in trying to solve the state's pollution problem in its rivers and Long Island Sound have resulted only in developing the inevitable conclusion that further progress cannot be expected "until a broader and more intelligent view of the whole problem is adopted."

The chief stumbling block is financial, as it was in Ohio, as Connecticut cities are limited in their capacity to borrow to 5 percent of the grand list. As all public undertakings must be financed out of this money, the competition with other and more popular projects leaves little for development and maintenance of sewer systems and sewage treatment. Mr. Wadhams declares that "unless this question of sewage disposal is regarded as an essential public utility, just as is the supply of a pure and wholesome water, no improvement in the present unfortunate situation can be expected."

He sees no essential difference between piping a water supply into a house and piping that same water supply out of a house after it has been converted into sewage. In conclusion he says:

"A proper conception of the whole subject would be to provide that the householder should pay for sewage removal in the same way as he does for the water supplied him, and on the same basis, that is, by a rate so fixed that it will bear the cost of the service so rendered."

Forms for Filtration Plant Reports

Recommendations of the Committee on Purification Data and Forms of the Water Purification Division of the American Water Works Association

By JOHN R. BAYLIS
Associate Editor

THE chief value of records is having them tabulated in convenient forms and filed so they are readily accessible. Then the performance of a plant may be told very quickly. This means that the essential data should be recorded on as few sheets as is possible. The commitee on Purification Data and Forms of the Water Purification Division of the American Water Works Association is to be commended upon the form they have gotten up for use in monthly reports.

The sheet has a line for each day of the month, and a place for all the data of importance. In fact it is supposed to be a flexible sheet in which such data as the operator considers essential for the operation of the plant may be recorded. If only one chemical is used for coagulating the water, only one heading for chemicals in the report is needed, whereas if three chemicals are used there should be three headings. All of the important tests that are made daily, or several times a month should have a place on the sheet. The sheet may be made most any length desired, for it is folded to letter size for filing.

It is essential that every filtration plant keep certain records, such as the amount of water treated, the amount of chemicals used, certain data on the filters, and certain chemical and bacteriological tests. The chemical and bacteriological tests should be made on the water before treatment, at certain stages of the treatment process, and on the finished product. The advantage of the form adopted by the committee is that the operator can decide on which of the tests are essential for his needs, and the sheet made of sufficient length to include all this data.

The advantage of having all, or as much of the essential data of a plant as possible recorded on one sheet should be apparent. Suppose the B. coli results are high for a day or more. The operator may wish to examine the records for the rate of filtration, the turbidity of the water in the several stages through the plant, the chemicals applied for coagulating the water, the chlorine used, the residual chlorine in the finished water, the B. coli content and bacterial counts through the several stages of the plant, and perhaps other factors, before he can decide definitely the cause for the high B. coli content.

With the data recorded as suggested by the committee, the operator can tell within a very few minutes what was done in the past for each character of water, and the results obtained, so that when there are similar conditions the desired treatment may be determined very quickly. If to do this involved searching through a mass of records which are on separate sheets and filed in different files, it very likely would not be done. The form suggested by the committee should be given very careful consideration by all who are in charge of the operation of filtration plants.

The report of the committee follows:

The Committee on Purification Data and Forms recommends that filter plant operators make their regular monthly reports of plant operation on forms similar to that submitted herewith, and that the following suggestions be given careful consideration:

1. The entire monthly report should be made on a single sheet exactly 11 in. wide and of sufficient length to meet all re-

Remarks:

Day	Million Gallons Treated	Filters: Units Washed	Filters: Average time of Service	Filters: Gallons Filtered per Square Foot per Minute	Filters: Gallons Wash Water	Filters: Per Cent Wash Water	Temp. Fahr.: Air	Temp. Fahr.: Water	Rainfall-inches	Alum: Pounds	Alum: Pounds per Million Gals.	Alum: Grains per Gallon	Iron: Pounds	Iron: Pounds per Million Gals.	Iron: Grains per Gallon	Lime-CaO: Pounds	Lime-CaO: Pounds per Million Gals.	Lime-CaO: Grains per Gallon	Record in this position copper sulphate, Ammonia, Potassium-permanganate, Soda Ash, etc.	Chlorine: Raw: Pounds	Chlorine: Raw: Pounds per Million Gals.	Chlorine: Raw: Parts per Million	Chlorine: Raw: Residual PPM Applied to Filter Effluent	Chlorine: Raw: Residual PPM Filter Effluent	Chlorine: Filtered: Pounds	Chlorine: Filtered: Pounds per Million Gals.	Chlorine: Filtered: Parts per Million	Chlorine: Filtered: Residual PPM Applied to Filter Effluent	Turbidity: Raw	Turbidity: Applied	Turbidity: Filtered	Color: Raw	Color: Filtered	Hardness: Raw	Hardness: Filtered	Soap: Raw	Soap: Filtered	pH: Raw	pH: Filtered
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Left Half of Form for Use of Filter Plant Operators in Making Their Regular Monthly Reports of Plant Operations

quirements. The reports can then be folded to 8½ in. x 11 in. size for binding or filing.

2. A 2 in. binding margin should be left on the left hand edge, and at least ¼ in. margin be left on the top, bottom, and right hand edges.
3. The report should be printed or reproduced on thin paper or tracing cloth, so that blue prints can be made.
4. No printing should be put on the back of the sheet.
5. Title should be placed in the upper right hand corner.
6. Remarks should be made in the space to the left of the title.
7. That "milliliter" should be substituted for "cubic centimeter."
8. That in filling in the forms under the head of B. coli, the fractional form be used, the denominator indicating the number of tubes tested, and the numerator indicating the number of tubes positive.
9. That in making annual reports the same general arrangements should be used, but the report should be separated into two sheets, grouping the physical and chemical data on one sheet, and that relating to micro-organisms and bacteria on another sheet. The spacing and lettering should be larger than on the regular monthly report so that photographic reproductions can be made. Monthly averages should be reported. Maximum and minimum results should be for the maximum and minimum day only.
10. If Soda Ash, Ammonia, Copper Sulphate, etc., are used, they should be reported in the position indicated, and where determinations such as Iron, CO_2, Manganese, Oxygen Consumed, etc., are made, they should be added in the position indicated on the blank form.
11. The Commitee realizes the impossibility of recommending a standard form that will meet the needs of every city. Each city finds it desirable to record certain data that would be of no particular value to other cities, but in order to compare the work of one filtration plant with another, it is very desirable insofar as possible, that each city preserves the same order in making reports.
12. The form as recommended by the Committee is particularly useful in permitting a detailed comparison of one filter plant with another. For instance, if it is desired to get an accurate picture of the bacteria growing on agar at 20°C, figures can be taken from the regular monthly reports and curves can be plotted on a single sheet showing graphically the number present in the water for each day in the year. The trend of filter plant performances can then be seen at a glance. If reports are exchanged with other cities and their results are similarly plotted, comparisons may be easily and definitely made. Each step in filter plant operation can be compared in a similar manner. Reports made of monthly averages only, are of very little value for comparing plant performances.
13. The report blank as recommended by the Committee not only represents its opinion, but seems to reflect a growing sentiment among filter plant operators. The Committee went to the trouble of securing blank forms that were used by cities in widely different sections of the country, and while the forms received varied in many particulars, there was a surprising similarity in the general type of many of their report blanks. In recommending this form, the Committee believes that it should prove flexible enough to meet the needs of most filter plants as they are operated today.

The Committee on Purification Data and Forms consists of the following: James W. Armstrong, Chairman, Julius W. Bugbee, Charles R. Cox, Jack J. Hinman, Jr., Harry E. Jordan, Thomas R. Lathrope, Winfield S. Mahlie, Richard Messer, Howard E. Moses, A. U. Sanderson, Wm. M. Wallace.

Sand Washing at Hartford Filters

A new record for speed of sand washing at the West Hartford filters of the water supply of Hartford, Conn., was made last year when two of the ½ acre beds were worked in three days. This was possible because, having the two ¾ acre beds in service, it was safe to have two of the ½ acre beds out of commission at the same time. The following account of the sand washing method is given by Caleb Mills Saville, Manager and Chief Engineer of the Water Department in the annual report for 1929 of the Board of Water Commissioners.

In washing, sand was ejected from the beds to the washers located alongside the sand bin. The clean sand from the water was dropped into another ejector and sent out into the sand bin, the water in which the sand was conveyed then overflowing into a wooden drain at the far side of the bin. Two ejectors were used; each ejector serving two washers arranged in parallel. Three beds were resanded during the year, two in the spring and early summer and one in the fall, and in resanding these, the so-called "Washington" method was used. Boxless ejectors were placed in the sand bin and the sand was conveyed from them to the separators. From the four separators the sand flowed into two ejectors and the mixed sand and water was sent through pipe lines and hose into the bed, discharging free from the hose nozzle.

Title

Record in this position, deter minations of Iron, CO_2, Manganese Oxygen consumed, dissolved Oxygen, or any record that may be necessary due to local requirements.	Micro Organisms: Raw — No. per ml.	Micro Organisms: Raw — Standard Units per ml.	Micro Organisms: Applied — No. per ml.	Micro Organisms: Applied — Standard Units per ml.	Bacteria Per ml. 20°C on Agar: Raw	Bacteria Per ml. 20°C on Agar: Applied	Bacteria Per ml. 20°C on Agar: Filtered	Bacteria Per ml. 20°C on Agar: Chlorinated	Bacteria Per ml. 37°C on Agar: Raw	Bacteria Per ml. 37°C on Agar: Applied	Bacteria Per ml. 37°C on Agar: Filtered	Bacteria Per ml. 37°C on Agar: Final Effluent	B. Coli: Presumtive Test in Lactose Broth: Raw: .001 ml.	.01 ml.	.1 ml.	1 ml.	10 ml.	Applied: .01 ml.	.1 ml.	1 ml.	10 ml.	Filtered: .1 ml.	1 ml.	10 ml.	Final Effluent: 1 ml.	10 ml.	Final Test by Isolation: Raw: .001 ml.	.01 ml.	.1 ml.	1 ml.	10 ml.	Settled: .01 ml.	.1 ml.	1 ml.	10 ml.	Filtered: .1 ml.	1 ml.	10 ml.	Final Effluent: 1 ml.	10 ml.	Day	Mineral Analyses Monthly Composite Parts Per Million	Raw Water	Filtered Water
																																								1	Silica (SiO_2)		
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													Number of Tests																													
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Month.

Year 19

Right Half of Form for Use of Filter Plant Opertors in Making Their Reguar Monthly Reports of Plant Operations

Determining the Efficiency of a Distribution System

Simplified Method of Making Direct Fire Flow Tests Through the Use of Existing Fire Hydrants

By MEYER SERKES

Assistant Engineer, Distribution Section, St. Louis Water Department, St. Louis, Mo.

IN the design of the distribution system of a moderate sized town of today, the selections of pipe sizes should be based upon the fire protection requirements.

The rates at which water must be supplied to furnish even moderately adequate fire protection, far exceeds that which is required for ordinary domestic consumption and manufacturing purposes.

Therefore great consideration should be given to the determination of the probable fire demands of a community and the methods as herein mentioned although simple, can very accurately determine the efficiency of your present distribution system to meet such requirements.

There are two principal methods of determining flows in distribution systems.

One, by use of the pitometer or pitot orifice tube, which is inserted into the main through a corporation cock. This method which is quite accurate requires some time for preparation and interpretation.

The other or simpler method is that of direct fire flow tests through the use of existing fire hydrants in your system.

Method of Measuring Hydrant Discharge.—The measurement of the discharge from a fire hydrant, although accurate for all practical purposes, can be made by any water works operator with ease and at very little expense. Sufficient information can thereby be obtained so as to enable one to know exactly what the system will do under almost maximum requirements.

The equipment used consists of a hydrant pitot blade about 4 in. long with a 3 in. pressure gauge attached to same and graduated in ½ lb. divisions, from zero to 50 lb. Several of these outfits should be used, so that two or more hydrant flows can be obtained at one time. Also an additional gauge graduated in 1 lb. divisions from zero to 150 or 200 lb. is necessary to obtain the static and residual pressure during the test.

In making a fire flow test, it is best to use the smaller outlets of the fire hydrant if such are available, as greater accuracy is thereby obtained.

The party making such tests should consist of two or more men, each equipped with a hydrant pitot blade with a gauge attached, and one man to observe the static and residual pressure during the test.

A group of hydrants within a block or two is chosen. At each hydrant an operator is stationed with a pitot blade. At a central hydrant or a house faucet, where no water is being used, a pressure gauge is attached from which the operator observes the static pressure, which is that pressure before the test is started, and the residual pressure or that during the test.

At a prearranged signal with each operator, the hydrants are opened simultaneously and the blades inserted in the stream to obtain the average velocity head emerging in pounds per square inch. The blade should be held about ½ in. from the face of the opening and should be traversed horizontally and vertically to observe the average maximum reading. This, in most cases, is found to be about in the center of the stream, but on large openings of 4 to 4½ in. it is advisable to take a rough average of the pressures across the stream in both directions.

It is best not to open too many outlets so as to lower the pressure in the mains to a figure below that assumed to be the minimum consistent with good fire service, which is 20 lb. where pumpers are used, and 60 to 75 lb. where effective streams direct from hydrants are resorted to. Generally, a test is satisfactory if sufficient water is drawn to lower the pressure in the main 10 or 15 lb. below the normal.

The diameter of each hydrant outlet should be recorded to the nearest 1/16 in.

Formulas for Determining Hydrant Discharge.—With the above observed data it is then very simple to obtain the discharges from the various hydrants from the following formula or tables which were made therefrom.

The formula used in determining the hydrant discharge is as follows:

Discharge in gallons per minute $= 26.9 \times d^2 \sqrt{P}$

Where d = internal diameter of hydrant nozzle in inches

p = the velocity head of the stream expressed in pounds per square inch as indicated by the pilot gauge.

This formula is derived as follows:

Since discharge = (area of outlet) × (average velocity). Using the formula for the area of a circle, and changing (d) to feet, and using the fundamental hydraulic formula Vel. $= \sqrt{2gh}$, changing (p) from pounds per square inch to feet head of water, the above formula becomes

Discharge in cubic feet per sec. $= \frac{3.1416 \times d^2}{4 \times 144} \times \sqrt{2g} \times \sqrt{2.31p}$

Discharge in cubic feet per sec. $= .00545 \times d^2 \times 12.2 \times \sqrt{p}$

Discharge in cubic feet per sec. $= .0665 \times d^2 \times \sqrt{p}$.

Discharge in gallons per min. $= .0665 \times d^2 \times \sqrt{p} \times 7.5 \times 60$

Discharge in gallons per min. $= 29.9 \times d^2 \times \sqrt{p}$

g = acceleration due to gravity = 32.2.

Using a coefficient of 0.90 which has been determined as an average for most hydrant outlets the formula becomes:

Discharge in gallons per min. $= 29.9 \times 0.90 \times d^2 \times \sqrt{p}$
$= 26.9 \times d^2 \times \sqrt{p}$

In making a fire flow test it is sometimes advisable to have another gauge attached to a hydrant outside of the group of hydrants being tested, so as to determine the loss of head in the main arteries.

Knowing the loss of head due to ordinary consumption, and the additional loss due to the measured flow from the hydrants, a very close approximation may be

Table Showing Discharge from Hydrants

DISCHARGE THROUGH CIRCULAR OUTLETS — COEFFICIENT .90 — GALLONS PER MINUTE — (2½)

PRESSURE	2¼"	2 5/16"	2 3/8"	2 7/16"	2½"	2 9/16"	2 5/8"	2 11/16"	PRESSURE	2¼"	2 5/16"	2 3/8"	2 7/16"	2½"	2 9/16"	2 5/8"	2 11/16"
¼	70	70	80	80	80	90	90	100	10 ¼	440	460	480	510	540	570	590	620
½	90	100	110	110	120	120	130	140	½	440	470	490	520	540	570	600	630
¾	120	120	130	140	140	150	160	170	¾	450	470	500	520	550	580	610	630
1	140	140	150	160	170	180	180	190	11	450	480	500	530	560	590	610	640
¼	150	160	170	180	190	200	210	220	¼	460	480	510	530	560	590	620	650
½	170	180	190	200	210	220	230	240	½	460	490	510	540	570	600	630	660
¾	180	190	200	210	220	230	240	260	¾	470	490	520	550	580	600	630	660
2	190	200	210	230	240	250	260	270	12	470	500	520	550	580	610	640	670
¼	200	220	230	240	250	260	280	290	½	480	510	540	560	590	620	650	690
½	220	230	240	250	270	280	290	310	13	490	520	550	570	610	640	670	700
¾	230	240	260	260	280	290	310	320	½	500	530	560	590	620	650	680	710
3	240	250	260	280	290	310	320	340	14	510	540	570	600	630	660	690	730
¼	250	260	270	290	300	320	330	350	½	520	550	580	610	640	670	700	740
½	250	270	280	300	310	330	350	360	15	530	560	590	620	650	680	720	750
¾	260	280	290	310	330	340	360	370	½	540	570	600	630	660	700	730	760
4	270	290	300	320	340	350	370	390	16	540	570	610	640	670	710	740	780
¼	280	300	310	330	350	360	380	400	½	550	580	620	650	680	720	750	790
½	290	300	320	340	360	370	390	410	17	560	590	620	660	690	730	760	800
¾	300	310	330	350	370	380	400	420	½	570	600	630	670	700	740	770	810
5	300	320	340	360	380	390	410	430	18	580	610	640	680	710	750	780	820
¼	310	330	350	370	390	400	420	440	½	590	620	650	690	720	760	790	830
½	320	340	350	370	390	410	430	450	19	590	630	660	700	730	770	810	840
¾	330	340	360	380	400	420	440	460	½	600	640	670	700	740	780	820	860
6	330	350	370	390	410	430	450	470	20	610	640	680	710	750	790	830	870
¼	340	360	380	400	420	440	460	480	21	620	660	690	730	770	810	850	880
½	350	370	390	410	430	450	470	490	22	640	670	710	750	790	830	870	910
¾	350	370	390	410	440	460	480	500	23	650	690	730	760	810	850	890	930
7	360	380	400	420	440	470	490	510	24	670	700	740	780	820	860	910	950
¼	370	390	410	430	450	480	500	520	25	680	720	760	800	840	880	920	970
½	370	390	410	440	460	480	510	560	26	690	730	770	810	860	900	940	990
¾	380	400	420	440	470	490	510	540	27	710	750	790	830	870	920	960	1010
8	380	410	430	450	480	500	520	550	28	720	760	800	840	890	930	970	1020
¼	390	420	430	460	480	510	530	560	29	730	770	820	860	910	950	990	1040
½	400	420	440	460	490	510	540	560	30	750	790	830	870	920	970	1010	1060
¾	400	420	450	470	500	520	550	570	31	760	800	840	890	940	980	1030	1080
9	410	430	450	480	500	530	550	580	32	770	810	860	900	950	1000	1040	1100
¼	410	440	460	480	510	540	560	580	33	780	820	870	920	970	1010	1060	1110
½	420	440	470	490	520	540	570	600	34	790	840	880	930	980	1030	1070	1130
¾	420	450	470	500	520	550	580	600	35	810	850	900	940	990	1040	1090	1140
10	430	450	480	500	530	560	580	610	36	820	860	910	960	1010	1060	1110	1160

made of the quantity available at any given pressure.

Great care should be taken in the selection of the hydrant, where the residual gauge is to be located as the accuracy of the test is hereby effected. It should be placed as close as possible to the center of the groups of hydrants from which the flows are to be measured.

With a known drop of pressure in the mains and with a known quantity of water drawn, it is comparatively easy by using a hydraulic slide rule to obtain the quantity of water available at any residual pressure.

This method can be used in connection with most tests, but cannot be used where the assumed residual pressure would lower the hydraulic grade line below the high point of any main between the pumps or supply works and the test.

In making flow tests and in studying the results, actual conditions at times of serious fires should be taken into consideration.

For example, tests made upon a system where a small standpipe is near the point of test would give an erroneous result, as the greater part of the flow for the first few minutes would come from the standpipe. In such cases it is best to make the test with the standpipe cut off.

Such fire flow tests when properly made and interpreted are indicative of numerous defects that may exist in a system, such as closed valves, acute bends, sediment in the main, or that the main in question is not properly interconnected with proximate feeders.

In all metropolitan cities of today such tests are continuously made to obtain data which is used as a basis in determining the reinforcements necessary in those sections where the fire supply has shown deficient.

All fire protection engineers of today, in making reports upon the adequacy and reliability of water systems, find that fire flow tests are undoubtedly the most practical, economical and most instructive method of studying the efficiency of a distribution system.

Such tests as these should be most profitable to water works engineers in designing and planning reinforcements to their distribution system, and in keeping well informed of the condition as it exists.

Determining Pressure Losses by Hydrant Flow Measurements.—Hydrant discharge measurements can likewise be made with sufficient accuracy in order to determine the friction coefficient or "C" in William and Hazens formula for mains ranging in size from 3 in. to 12 in. For the larger mains a great number of hydrants would be required to be opened in order to obtain a velocity greater than 1 foot per second, so as to insure any degree of accuracy.

In making such tests the main in question must be isolated, so that the same amount of water passes the two points at which the instruments are attached. In other words the supply must come from one end only and leave through the discharge openings which are being measured. All large service connections or branch connections must be shut so as to have a uniform velocity across the entire stretch.

There are two methods of obtaining the pressure losses required for the determination of "C."

Table Showing Discharge from Hydrants

DISCHARGE THROUGH CIRCULAR OUTLETS — COEFFICENT .90 — GALLONS PER MINUTE — (4½)

PRES BURE	4¼"	4 5/16"	4 3/8"	4 7/16"	4½"	4 9/16"	4 5/8"	4 11/16"	PRESSURE	4¼"	4 5/16"	4 3/8"	4 7/16"	4½"	4 9/16"	4 5/8"	4 11/16"
¼	240	250	260	270	270	280	290	300	10 ¼	1560	1600	1650	1700	1740	1790	1840	1890
½	340	350	370	380	390	400	410	420	½	1580	1620	1670	1720	1760	1810	1860	1910
¾	420	430	450	460	470	490	500	510	¾	1590	1640	1690	1740	1790	1880	1880	1940
1	490	500	520	530	550	560	570	590	11	1610	1660	1710	1760	1810	1860	1910	1960
¼	540	560	590	590	610	630	650	660	¼	1630	1680	1730	1780	1830	1880	1930	1980
½	600	610	630	650	670	690	700	720	½	1650	1700	1750	1800	1850	1900	1950	2000
¾	640	660	690	700	720	740	760	780	¾	1670	1720	1760	1820	1870	1920	1970	2020
2	690	710	730	750	770	790	810	840	12	1690	1730	1780	1840	1890	1940	1990	2050
¼	730	750	780	800	820	840	860	890	½	1720	1770	1820	1870	1930	1980	2030	2090
½	770	790	820	840	860	890	910	940	13	1750	1800	1860	1910	1970	2020	2070	2130
¾	810	830	860	880	900	930	950	980	½	1790	1840	1880	1950	2000	2060	2110	2170
3	840	870	900	920	940	970	1000	1020	14	1820	1870	1930	1980	2040	2090	2150	2210
¼	880	900	930	960	980	1010	1040	1060	½	1850	1910	1960	2020	2080	2130	2190	2250
½	910	940	970	990	1020	1050	1070	1100	15	1880	1940	1990	2050	2110	2170	2230	2290
¾	940	970	1000	1030	1050	1080	1110	1140	½	1920	1970	2030	2090	2150	2200	2260	2330
4	970	1000	1030	1060	1090	1120	1150	1180	16	1950	2000	2060	2120	2180	2240	2300	2360
¼	1000	1030	1060	1090	1120	1150	1180	1220	½	1980	2030	2090	2150	2210	2270	2330	2400
½	1030	1060	1090	1120	1160	1190	1220	1250	17	2010	2060	2120	2180	2250	2310	2370	2440
¾	1060	1090	1120	1150	1190	1220	1250	1290	½	2040	2090	2160	2220	2280	2340	2400	2470
5	1090	1120	1150	1190	1220	1250	1280	1320	18	2060	2130	2180	2250	2310	2370	2440	2510
¼	1110	1150	1180	1210	1250	1280	1320	1350	½	2090	2150	2220	2280	2350	2410	2470	2540
½	1140	1180	1210	1240	1280	1310	1350	1390	19	2120	2180	2250	2310	2380	2440	2510	2580
¾	1170	1200	1240	1270	1310	1340	1380	1420	½	2150	2210	2280	2340	2410	2470	2540	2610
6	1190	1230	1260	1300	1330	1370	1410	1450	20	2180	2240	2300	2370	2440	2500	2570	2640
¼	1220	1250	1290	1320	1360	1400	1440	1480	21	2230	2290	2360	2430	2500	2560	2630	2710
½	1240	1280	1310	1350	1390	1430	1470	1510	22	2290	2350	2420	2490	2560	2620	2700	2770
¾	1260	1300	1340	1380	1420	1450	1490	1540	23	2340	2400	2470	2540	2610	2690	2760	2820
7	1290	1330	1360	1400	1440	1480	1520	1560	24	2380	2460	2520	2600	2670	2740	2820	2900
¼	1310	1350	1390	1430	1470	1510	1550	1590	25	2430	2510	2580	2650	2720	2800	2870	2960
½	1330	1370	1410	1450	1490	1530	1570	1620	26	2480	2550	2630	2700	2780	2850	2930	3020
¾	1350	1390	1430	1480	1520	1560	1600	1640	27	2530	2600	2680	2760	2830	2910	2990	3070
8	1380	1420	1460	1500	1540	1580	1620	1670	28	2580	2650	2730	2800	2880	2960	3040	3130
¼	1400	1440	1480	1520	1570	1610	1650	1700	29	2620	2700	2770	2850	2940	3020	3090	3180
½	1420	1460	1500	1540	1590	1630	1680	1720	30	2670	2740	2820	2900	2990	3070	3150	3240
¾	1440	1480	1520	1570	1610	1650	1700	1750	31	2710	2790	2870	2950	3030	3120	3200	3290
9	1460	1500	1540	1590	1630	1680	1720	1770	32	2750	2830	2920	3000	3080	3170	3250	3340
¼	1480	1520	1570	1610	1660	1700	1750	1800	33	2800	2880	2960	3040	3130	3220	3300	3390
½	1500	1540	1590	1630	1680	1720	1770	1820	34	2840	2920	3000	3090	3190	3260	3350	3440
¾	1520	1560	1610	1650	1700	1750	1790	1840	35	2880	2960	3050	3140	3210	3310	3400	3500
10	1540	1580	1630	1670	1720	1770	1820	1870	36	2920	3000	3090	3180	3270	3360	3450	3540

One by the use of ordinary pressure gauges, the other by use of the sensitive differential gauge.

In using ordinary pressure gauges, greater stretches of pipe can be taken, whereas with the differential gauge only lengths from 300 to 700 feet, in most cases, are economically available for test.

In using pressure gauges, two hydrants, some known distance apart are chosen, at which the gauges are attached and the correct elevation of these gauges determined. If possible sensitive gauges reading as close as one foot head should be used, if available.

Computing Loss of Head.—One or more hydrants are opened from which the amounts of water flowing is obtained by use of the pilot blade, and the pressures observed simultaneous at the gauges. Having obtained this data, the loss of head and the friction coefficient can be readily computed by the ordinary formulas:

Quantity of discharge = Velocity × Area of pipe or

$$\text{Vel.} = \frac{\text{Quantity}}{\text{Area}};$$

Substituting Velocity in Chezy's formula, Vel. in ft. per sec. $= C\sqrt{RS}$:

where R = Hydraulic radius $= \frac{\text{Diameter of pipe in ft.}}{4}$

S = Slope per foot of pipe

and solving for "C" the friction coefficient.

In the use of the simple differential pressure gauge, a short stretch of main between two fire hydrants, house service taps or faucets can be used.

Within the differential gauge, which is merely a "U" tube 10 or 20 in. high, a liquid heavier than water is placed, such as carbon-tetrachloride, Bromoform, or mercury, as may be needed.

The "U" tube is connected up by means of ordinary garden hose to each fire hydrant or house faucet, making sure that no leak occurs on any part of the hose connection, house faucet, or service pipe.

In this test one fire hydrant is usually sufficient to be opened and the discharge observed by the pilot blade or by means of a 3 or 4 in. accurate meter attached to the hydrant.

While the discharge is being measured by one observer, the deflection in inches or the direct pressure loss at the differential gauge is observed by another. Should the deflection be too great to be observed within the range of the "U" tube by the use of carbon-tetrachloride, the solution should be changed to Bromoform, or mercury.

Thirty second readings for 5 or 10 minutes should be taken in both tests, either at the gauges or at the deflection tube so that fair averages are obtained.

Knowing the distance between the hydrants or points at which the hoses were attached, it then becomes a problem of again solving for "C" in the Chezy's formula. $V = C\sqrt{RS}$.

The head loss between the two points in the main as observed by the deflection on the differential gauge is as follows:

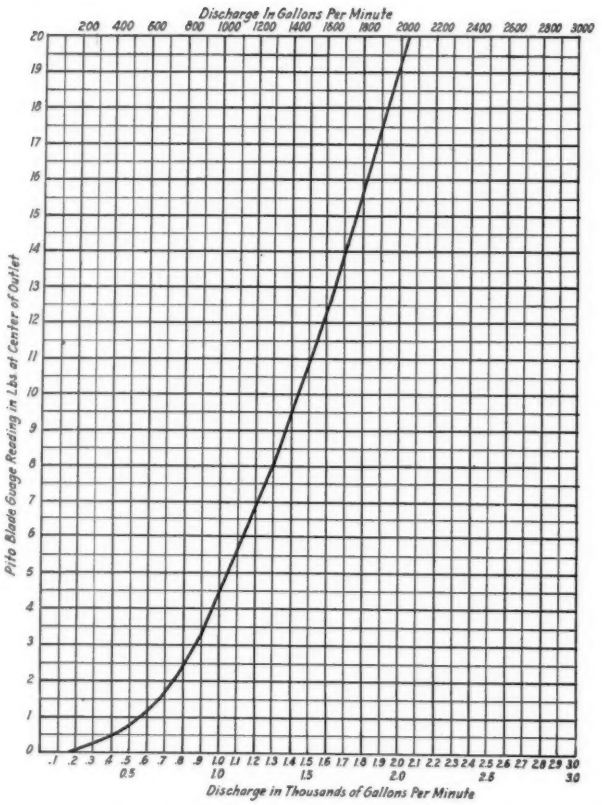
$$\text{Head loss in feet} = d\frac{s^1 - s}{s}$$

in which d = deflection in feet

s^1 = specific gravity of heavy liquid

s = specific gravity of water

Gravity of carbon-tetrachloride	1.60
Bromoform	2.75
Mercury	13.58



Curve Showing Actual Flow for 4½ In Fire Hydrant Outlet

If a hydraulic slide rule is available the "C" can very readily be obtained by knowing velocity in feet per second, slope in feet per 1,000 ft. and diameter of the pipe.

The "C" or friction coefficient thus obtained can then be compared with the "C" for various ages of pipe as in William & Hazen Hydraulic Tables, whereby a fair idea of the interior condition of the pipe is determined. "C" for new pipe ranging from 120 to 130.

Such tests as those along sections of mains are valuable in locating obstructions or partly closed valves, by noting unequal drops of pressure or losses in different sections of the pipe length. It can also be used in determining the necessity of cleaning a main or its effectiveness after cleaning has been accomplished.

Acknowledgment.—The foregoing is a paper presented Oct. 24 at the 6th annual Missouri Water and Sewerage Conference.

WATER MAINS LAID ON TOP OF GROUND.—The installation of water works for the city of Churchill, the northern terminus of the Hudson Bay Ry. in Ontario, involved an interesting problem as ordinary methods of laying the mains below the frost line were not suitable.

Borings as deep as 117 ft. have reached solid rock before coming to the end of the frozen soil which never thaws out. It is stated the mains will be laid on top of the ground and covered all around with 4 ft. of dry moss. The pipes will be supported on wooden posts driven into the clay, and when covered with the moss, will be sheeted with sheet iron and thatched straw to prevent the moss from getting wet, thus turning it into a good conductor of cold.

Automatic Water Pumping Stations at Baltimore

Elements of Design Entering into Automatic Electric Stations and Operating Experiences with Certain Features of Such Stations

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THIS subject should be one of lively interest to those engaged in water works practice, as the economies to be gained by an automatic system of operation which permits the absence of an operating personnel, are quite marked. There may be an impression that the absence of attendants in such a station mitigates against the reliability of the plant operation, but the writer submits that this consideration, while of prime importance generally in water works service, is not a serious factor, and with the increased reliability that has developed in the past few years in power supply control apparatus, and the other elements upon which the continuous service of a pumping station is dependent, the automatic station stands alone in its field. In line with this thought, it may be generally considered as axiomatic that with any electrically operated machinery, whatever can be done by manual control can be done better by automatic electrical control, and an experience of a number of years in the design, construction and operation of electrically powered pumping stations has convinced the writer of the truth of this assertion.

The present discussion will be limited to electrically operated automatic stations, without prime mover emergency stand-by units, discharging into a standpipe or similar means of reserve, as it is considered that the application of such stations is limited to this class of service. In this connection, it should be noted that, while this discussion is confined to an electrical drive, the automatic operation is not necessarily limited to this, but it may be applied, with proper adaptation, to gasoline or oil engine drives, combinations of these with motor drives, or other suitable sources and combinations of energy that may be selected, and with the pumps discharging into open or closed systems.

The Pumping Station.—The housing of the equipment for an automatic station is a most important consideration and the two elements that should be carefully considered in this connection are those for the protection against freezing and provision for proper drainage. Any freezing protection dependent upon artificial heat, such as electric heating units, is not thoroughly dependable, and in two instances in Baltimore where electrical heating was provided for freezing protection in an automatic station, the heating system has failed, resulting in the breakdown of the control system and expensive repairs to Venturi meters, gauges, and other water-actuated apparatus. The station in which this damage was done was not designed or built by the city, but was acquired and operated by the municipality in connection with the expansion of the water supply system that has followed the Annexation Act of 1918; we mention this to explain the apparent inconsistency between our theory and our practice in this connection.

The most effective, economical and certain way of protecting against freezing is to place the main portion of the structure below ground, with sufficient earth covering above to insure that freezing temperatures will never obtain in the pump room. All of the stations that we have designed and built have been constructed along these lines, and it has been found that with an 18 in. covering of earth over the top slab of the buried portion of the structure, the lowest temperature reached in a pump room has been 35° F., this being at a time when the outside temperature during the night fell to 5° below zero and the operation of the pumping machinery, with its consequent generation of heat, had been suspended for a period of more than four hours. To gain access to the pump rooms, these stations are built with a structure outside the wall of the main portion to form a stairwell, and in this construction is included an arrangement of two doors, one at a middle landing on the steps and one at the bottom of the steps where it enters the pump room, these forming an air lock to arrest the transfer of heat by way of the stairwell construction. The opening of the stairwell at the ground level is surmounted by a brick structure about eight feet square in plan, and within this there is placed the electrical service entrance and metering equipment. The outside door is arranged with a double hasp locking device, with separate locks for water bureau and power company employees, and by this means the power company can gain access at all times for reading the meters; the next door on the middle landing below can be opened only by Water Bureau employees. The structures are arranged in each case so that the entrance door faces toward the south and opens in, this detail being one intended to give the minimum interference with access to the building which may result from heavy snowfalls or freezing weather. The size and arrangement of the stairwells is such that the large machinery cannot be readily passed to the pump room, and to provide for the handling of such equipment, the top slab is pierced with a suitable sized opening having walls extended above the ground level, this opening, when not in use, being closed with a heavy concrete slab built with overhanging edges. To give proper ventilation in warm weather, the top edge of the opening in which the cover slab rests are provided with a series of 3 in. depressions, and these, together with the projection of the cover slab, permit the escape of heated air, at the same time forming effective protection against the elements. In addition to this ventilating arrangement, we have provided in each structure a short section of 16 in. pipe leading through the top slab to above the ground surface, this being intended to receive a ventilating fan, if such an arrangement would be found necessary in extremely warm weather, but so far with the stations we have built, the ventilating fan has been found unnecessary.

Location of Station.—The location of the structure under ground may introduce difficulties in some localities on account of drainage, but in Baltimore we have been fortunate in our permissible choice of topography

and in every case have been able to obtain a gravity drainage line. Where conditions would not permit gravity drainage and sump pumpage would have to be resorted to, a dual arrangement of both electrically operated and water ejector means of sump unwatering should be adopted, as an accumulation of water which might follow the failure of an unwatering system, would be highly undesirable, to say the least. In addition to the necessity for getting rid of waste water which accumulates in the station sump incident to operation, it is also necessary to keep surface drainage from penetrating the structure and creating a damp condition. To satisfy this requirement, the entire structure from the ground line to the bottom of the wall footings should be protected by a membrane waterproofing, with an outside tile drain line carried around the footings and led into the sump. The last station we have built includes this method of waterproofing, and the results have been very satisfactory, notwithstanding the location of the station at an elevation considerably below the bottom of an adjacent reservoir.

The Electric Service.—The equipment for the station should be divided into two or more units, and if two units are used, these should be in duplicate and interchangeable to permit a transfer of a portion of one unit to the other in case this is necessary. The electric service to the station should be brought in underground from the pole line, and this arrangement, while somewhat more costly initially, contributes considerably to the neatness of appearance of the surroundings and allows complete freedom of choice as to the direction in which the service is brought. In addition, the underground arrangement gives the very practical benefit of minimizing the effects of lightning discharges on the power lines, and even with a direct stroke immediately at the point where the service is taken from the pole line, the effects of the lightning discharge, if it followed the station service, would be dissipated in the ground before it would expend its force on the station equipment. The most serious trouble with station apparatus which we have had from lightning, with the underground power lead-in, has been the effects of line voltage surges which accompany the stroke, and in one instance, this caused the breakdown of the insulation on a no-voltage holding coil. A properly functioning lightning arrester will not afford better protection against the effects of lightning and the underground lead-in gives practically the same results as an arrester, with the additional advantages that have been indicated, as well as being free of the necessity for maintenance attention which the arrester requires.

From the service entrance the circuit should be led through a fused disconnecting switch to the control panel, with the fuses of such capacity as to be the strongest link in the chain of over-current protection devices, but not so strong as to fail only after permanent damage has been suffered by the apparatus in the event of an over-current condition. For stations of the size we are considering, 440 volts is our standard potential and this permits the circuit to be handled through an air type breaker mounted on the station control panel. This breaker should be provided with magnetic overload protection, with means for ready calibration, but a no-voltage release device should not be included on the breaker unless the latter is of the automatic reclosing type, as a momentary voltage dip may cause the no-voltage release device to open the breaker and the station would be inoperative until attention was received. After leaving the main breaker, the circuit should be carried through the desired metering instrument elements and led to a bus construction from which the two or more motors in the station are fed. Each circuit feeding the motor should take off through a disconnecting switch so that the opening of this will kill the corresponding motor and starter and thus permit repairs to be carried on without interfering with the operation of the remainder of the station equipment.

Motor Starters.—The type of motor starters that may be used depends upon the kind of motor that is selected and the starting current limitations of the power company. A variety of starters for performing the required service are available, and the proper choice depends upon the local conditions to be met. Whatever starter is selected, it should be provided with thermal overload protection in two phases, and so constructed as to be able to withstand successfully a number of starts in close succession. Such starters with automatic operation being dependent upon magnetically-operated contacts, inherently include no-voltage protection and for this reason, the omission of a no-voltage release on the main panel breaker, referred to above, is of minor importance. However, if the power supply is subject to interruptions, particularly partial ones resulting in single phase service, these may be provided against by the proper arrangement of potential and current phase balance relays, timing relays, and re-closing breakers; with such apparatus, the equipment will open the circuits upon the development of partial or complete faults, wait a definite interval to allow apparatus to cool or a fault to be corrected, reclose circuits at the expiration of an interval or when phase potentials are in balance and in any similar predetermined manner follow orders explicitly, without the necessity of having them repeated or typed and posted on a bulletin board, and with never a thought of a vacation, days off to attend to private business, or a demand for overtime for performing this service twenty-four hours daily.

Either the squirrel cage or the wound rotor induction motors are available for service such as we are considering; synchronous motors, of course, may also be chosen, but unless there are strong inducements offered for their use by the power company wishing to gain the benefits of the power factor correction feature of the synchronous motor, the comparative complications of this type do not commend them for the presently-considered form of application. The squirrel cage induction motor presents advantages over the other types, among which may be noted lower first cost, simplicity and ruggedness, high efficiency, and the ability to operate at higher speeds safely. Their application generally, however, is handicapped by the high starting current inrush that is a squirrel cage characteristic, although recent designs of deep bar and double cage windings on squirrel cage rotors have improved these motors to an extent that has considerably enlarged the field of squirrel cage application which has been limited in the past by the starting characteristics. It should be noted that the limitations on the use of squirrel cage motors relate to and are governed by the power company's restrictions on permissible starting currents, and aside from these considerations, the squirrel cage characteristics do not handicap the design of the station equipment. With a properly designed squirrel cage motor and starter, and special provisions made to limit the load on the motor until the machine is up to speed, however, a starting inrush of 200 per cent of normal current can easily be met, and there are applications in Baltimore in which large squirrel cage motors up to 500 and 1,000 hp. are being started with a 150 per cent current limit.

The wound rotor induction motor offers a ready solution in the event that the squirrel cage application cannot be worked out, and the installation of this type will usually simplify the starting equipment to an extent that apparently indicates the wound rotor motor is a preferable one from an over-all viewpoint. It should be borne in mind, however, that upon the motor depends to a large extent the successful operation of the station, and the primarily apparent advantages which may appear from the installation of a wound rotor drive, should not be allowed to overbalance the lasting benefits of maximum dependability that is an outstanding quality of the squirrel cage construction.

The Equipment Control System.—One of the most important features of an automatic station is the control system by which the operation of the equipment is governed. The systems by which the head of water in the reservoir or standpipe governs the pumping equipment fall into three general classes: 1—float switch in the tank, with control wires led back to the station; 2—separate pressure line from the tank to the station; 3—altitude valve at tank, arranged to close when the tank is full and in this manner build up pressure on the entire distribution system above the normal operating point, thus effecting the function desired.

Of these three general schemes, the float switch is the least desirable in water works practice, due to the complications that are brought about by freezing and the necessity for maintaining the control wires from the tank to the station. It is the simplest method, however, and where the distances are short and climatic conditions are favorable or proper means can be provided for overcoming the effects of ice on the float, this method is acceptable and, no doubt, is used in a large number of cases.

The separate pressure line between the tank and the station, although overcoming the objection on the grounds of freezing that handicaps the float switch method, entails considerable installation expense, and the pressure line is a weakness that must be constantly protected to insure the continuity of station operation. In addition to these disadvantages, the direct pressure system may, in some installations, give an operating range for control that is a very small percentage of the total head pumped against, and as pressure actuated contact making devices are none too sensitive at best, any system in which the total range of pressures between the start and stop positions is a small proportion of the total pressure that must be borne by the contact gauge, should be avoided. This system also presents the disadvantage of making and breaking contacts very slowly, with the detrimental results that always follow such procedure. We have one installation in Baltimore that has been temporarily working on this direct pressure system and the initiation of its use developed an unusual and totally unexpected condition. The contact gauge controlled by the pressure pipe was mounted on a small sub-panel along with a relay controlled by the gauge, the relay being so constructed that upon closure it would latch in mechanically and remain latched until the standpipe was filled. As the standpipe emptied, the gauge contact would slowly approach the starting position and finally make contact very lightly, so that the relay would draw its armature into the closed position to latch. The movement of the relay jarred the panel upon which it was mounted sufficiently to momentarily open the gauge contacts before the relay latch caught, with the result that the relay armature would fall out again, this cycle continuing with destructive effects on the entire control system until the standpipe pressure fell low enough to effect a positive gauge contact closure; the trouble was overcome only by physically separating the contact gauge and relay; this incident is brought out to illustrate one of the disadvantages that may follow the use of the direct pressure control systems, with the slow closure of contacts that is a concomitant of this system.

The third method outlined offers the cheapest and most satisfactory and reliable method of control operation that has been developed. To repeat, this system consists of an altitude valve placed in the discharge line where it enters the standpipe or reservoir, arranged to shut when the tank reaches the desired level and open again after the level has fallen four or more feet. A by-pass, with check valve, is inserted around the altitude valve to permit the tank to discharge into the system after the pumps are shut down and before the altitude valve re-opens. This method of control offers the advantage of having all the elements gathered at one point in an underground frostproof vault, and under normal conditions nothing short of a break in the distribution system can disarrange its operation. Its use also simplifies the adjustment of the control devices in the station, as the system pressure, when the standpipe is full and the altitude valve closes, builds up abruptly and definitely, giving a positive cut-off point that is not dependent upon close or maintained adjustment.

All of the stations in Baltimore, except the one mentioned with the temporary direct pressure system, are operating, or are being designed and constructed to operate, on the altitude valve control method, these installations ranging in size up to stations having individual units with capacities of 10,000 g.p.m. One station now under construction will be controlled by an altitude valve installation at a reservoir, with the altitude valve governed by a hydrostatic head-mercury balance device that is sufficiently sensitive to cause the altitude valve to open and shut from a range in reservoir levels of not more than six inches. In this particular installation, closure of the altitude valve will shut down the station, the pump will start again at the expiration of a pre-determined time interval which is initiated coincidentally with the preceding shut-down operation. Controlling the start in this manner avoids the uncertainty which would otherwise result from an attempt to control by pressure drop, where the greatest permissible reservoir water level range represents a head that is but a small proportion of the total head on the pumping system.

Pressure Wave Dampening Tank.—A point that is often overlooked in the design of station control apparatus is the necessity of a pressure wave damping tank in the lines leading to the contact gauges. Without such devices the contact gauges will follow the amplitude of the pressure surges that occur subsequent to the shutting down of a pump, and not infrequently the discharge main pressure will dip sufficiently low, immediately following a pump shut-down, to cause the equipment to start again. This, of course, results in the immediate building up of a pressure head to the shut-off point, and the unit again shuts down, only to be followed by another cycle of starting and stopping. In one instance the writer knows of an installation without a damping tank in which a unit started and stopped in this manner two times a minute for thirteen hours, with results to the starting equipment that can well be imagined, not to mention six failures in the distribution system during this period. In a Bourdon tube type of pressure gauge, but a few drops of water are required to be introduced into the tube to cause the gauge to go through its entire range, and from this can

be realized the futility of attempting to damp the contact gauge action by a throttling device only. An air chamber of about five gallons capacity introduced in the gauge line, behind a needle valve or fixed orifice inserted in the pressure line between the discharge main and the tank, will give all the damping effect that is necessary, and such a device will permit pressures to be transmited very slowly to the contact gauge, at the same time giving a positive control of fluctuations.

The Pumps.—The choice of pumps for an automatic station depends upon the conditions to be met and a discussion of the kinds that are available is not a part of this article. The centrifugal pump, of course, is almost universally used, but the displacement type of any kind is as adaptable to automatic operation as is the centrifugal. In a centrifugal pump installation, however, it should be borne in mind, where the system is to be controlled by the altitude valve method, that the discharge head conditions of the distribution system must be carefully considered, and the head-discharge characteristics of the pump should be such that sufficient head is developed to give an ample operating range when the altitude valve closes. Similarly, for a displacement pump installation to be controlled by an altitude valve, the possible effects of high pressures building up after altitude valve closure should not be overlooked, and proper provisions made to guard against the creation of what may readily become destructive pressure valves.

With an underground station such as we have indicated as being desirable, there is usually no difficulty about priming the pumps if centrifugals are selected, but if priming is a condition that must be met, automatic priming has been successfully developed and used over a sufficient period of time to demonstrate its entire dependability. If priming must be a part of the station operation, this feature requires merely another element that must be provided in the starting equipment before the main pumps are placed in service.

Valves.—Station valves would seem to be a form of equipment so old and well developed as to be beyond the scope of discussion, but it is surprising what an amount of trouble can be gotten into unless proper attention is paid to these details. Check valves in the discharge lines are particular offenders and if they are the usual swinging disc type and put in the line without any thought of subsequent maintenance, the disc may soon wear and drop from its hinge pin, particularly if the demands on the distribution system are subject to severe fluctuations. In Baltimore, more than one disc has disappeared from a check valve without leaving any notice of its departure and in some instances, they have worn so as to cock into a partly open position on closure, and then slam shut when the full reverse flow developed; in one instance this caused a water hammer that resulted in a complete rupture of the check valve body. Where fluctuations may be expected or developed, the swinging disc type of check valve may be given long life and be comparatively trouble free if it is blocked so that it cannot swing freely and entirely open, but is always held steady in the allowed open position, with a positive pressure against the stop. There may be a technical objection to this on the grounds of increased friction losses, but we believe any determination of losses resulting from this procedure would be practically limited to a theoretical discussion, and the reliability of the check valve, together with the absence of necessity for maintenance, which follows the use of the blocking method, more than makes up for any actual losses that result.

The pump discharge valves in the usual layout of automatic stations are generally open, with the water held by a check valve. Such an arrangement permits the pump to impose a load on its motor as soon as the speed reaches the point where the head developed is sufficient to lift the check valve against the distribution system pressure; often this condition is highly undesirable, as it means that the motor is being placed under load before it is in the full running position. Such a station design and operation presents an unnecessary handicap upon the use of a squirrel cage motor, with its less favorable starting qualities, and the cause for such conditions may be readily avoided by the proper attention to design. In Baltimore, the solution of this problem is found by having the discharge valves hydraulically operated and automatically controlled, and shut when the pump unit is down. The admission of water to the hydraulic operating cylinder is controlled by a pilot valve, this being governed in turn by a mechanism which is normally held in the "off" position by spring pressure, with the force of the spring being overcome by water pressure in an auxiliary hydraulic cylinder, the latter being connected by a pressure line to the pump discharge nozzle. By this means, a pump is started and brought up to speed before the discharge valve is open, in this manner limiting the load on the motor to between 35 and 40 per cent of full load until the running contacts of the motor starter are closed. Succeeding the shut-down of the pump, the hydraulic valve control device returns the discharge valve to the closed position, this system affording double protection in the event of a check valve failure, as well as, through limiting the starting load permitting the application of the more desirable squirrel cage motor under conditions where otherwise the squirrel cage type may not have been acceptable to the power company.

Acknowledgment—The above is an abstract of a paper presented at the 4th annual conference of the Maryland Water and Sewerage Association.

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Eliminating Unnecessary Use of Fire Hydrants

In the superintendent's round table (see October Journal American Water Works Association) at the 1930 convention of the association, C. W. Winkle, superintendent, maintenance and transportation, Indianapolis, Ind., Water Co., stated that in an effort to eliminate all unnecessary use of public fire hydrants in Indianapolis, the Indianapolis Water Co. set aside 20 smaller type fire hydrants in the high value district, and these were equipped with special 1⅞-in. inside diameter connections for use by the street flushing crews, or other city employes charged with the use of city water. In addition, 1⅞-in. inside diameter connections were placed on one nozzle of approximately 175 fire hydrants in the city, and the street sweeping and flushing crews make connection with these 1⅞-in. inside diameter outlets. All of the city street flushing or street sweeping equipment is provided with special 1⅞-in. connections, thereby making it impossible for them to connect to the regular 2½-in. fire hydrant outlet. This plan, while placing a burden of expense on the company, has been of immeasurable value in safeguarding the good working condition of the public fire hydrants.

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The Cause of Certain Weather Anomalies

ONE of the most puzzling features about rainfall has been the fact that in years when certain areas in the northern hemisphere are supernormal others are subnormal in rainfall. However, the riddle may be solved by the electron theory, provided that that theory is used to explain the existence of the permanent cyclonic and anticyclonic whirls.

Turn to Encyclopedia Britannica, under Climate, and you will see six permanent anticyclone areas near the tropics, three north of the equator and three south of it. These are areas of high barometric pressure, due to the fact that the whirling air is descending. North of the equator the three permanent anticyclones are rotating clockwise, whereas the three south of the equator are rotating anticlockwise. Note that their centers are about 120 degs. apart in longitude. Note also that there are two very pronounced permanent cyclones, rotating anticlockwise, one having its center in Bering Sea, near Alaska, and one near Iceland. Then observe that two of the great anticyclones lie almost south, but slightly to the east of these arctic cyclones. This raises the thought that each of these anticyclones may be the tail end of a cyclone to the north. The Alaskan cyclonic whirl apparently ascends, bends over and descends as the anticyclone in the Pacific between Hawaii and California. There are several facts that support this inference, notably the fact that at times when the Alaskan whirl is strongest, the north Pacific whirl is strongest and has its center farthest south. It is significant also that sunspots, similarly occur in pairs that are rotating in opposite directions.

By aid of topographical uplifts that lie on the arcs of circles, the editor has inferred that there are 13 great cyclonic whirl-belts of molten matter whose centers were nearly stationary during the uplift of such arcs as the Aleutian Islands, the southwest coast of Greenland, the north and northwest coasts of South America and Africa, the arc-like string of islands starting with Sumatra, etc. The evidence is strong that many of these molten-whirls still exist, and that above them there are permanent cyclonic whirls in the air. The electron theory suffices to explain all such whirl-belts in fluids, as well as to explain the rather symmetrical arrangement and the relative permanence of the whirl centers.

Since electrons are known to cause condensation of atmospheric moisture, the basis of a complete theory of air circulation and rainfall is thus furnished. Since cyclonic whirls in the northern hemisphere are opposed in direction to those in the southern hemisphere, it follows that they must have opposite magnetic polarity if they are caused by electrons revolving in orbits about the whirl centers. Being opposite in magnetism they would be oppositely affected by any external magnetic field, such as that of the sun or a sunspot or a planet. This explains why the seasonal precipitation near the arctic circle reaches its maximum when it is a minimum near the antarctic circle, and vice versa; and it explains other similar differences in those two hemispheres. But it does not explain why India may have a drought during a year when California has excessive rainfall. If California receives an increment in electron density from the Alaskan cyclone, it receives increased rainfall. But if the anticyclone in the Indian Ocean moves farther away from its cyclonic source whose center is near the Philippine Islands, then the customary summer monsoons due to that anticyclone fail to be as strong as usual, and less moist, air sweeps over India, resulting in deficient rainfall. Similarly the shifting of the anticyclone whose cyclonic origin is in Africa affects the summer rainfall in the region of the Gulf of Mexico and our southern and central states.

Remembering that the Arctic Circle permanent cyclones are strongest about the end of September, whereas those near the Tropic of Cancer are strongest about March, it is easy to see why a summer drought in the Gulf of Mexico region may be followed by a supernormal winter precipitation in America.

Certain meteorologists have objected to the theory that solar or planetary magnetism affects our weather on the ground that it should affect the entire world alike. To begin with such an argument fails to take into consideration the opposite magnetic polarity of the north and south hemispheres; but of equal importance is the failure to recognize the fact that the earth is a compound magnet, and that its Heaviside layer of electrons, in the upper atmosphere is probably a compound magnet also; under the influence of these lower and upper magnetic fields, and of the magnetic fields due to the sun and planets, the electron density varies in the earth's atmosphere because of electron migrations. Winds and rainfall, being primarily due to atmospheric electrons, consequently vary in a systematic and understandable manner.

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Financing Water Works Extensions and Improvements Out of Revenues

THE gasoline tax has become the most popular method of securing money with which to build roads. Every state in the Union now has such a tax. Formerly many a bond issue for road improvement was voted down not because such improvements were not needed, but because taxpayers usually dislike incurring a large indebtedness. Now the same taxpayers willingly finance enormous highway projects every year by means of taxes on gasoline.

Reasoning by analogy it seems probable that desirable

enlargements, extensions and improvements of waterworks systems could be effected by slightly increasing present water rates. Many of the most successful industrial companies make it their practice to finance practically all their additions to plant out of earnings. Ford is a striking example of the success of this method of financing improvements. Not a few city water departments have successfully practiced the same business policy. But seldom have water rates been high enough to furnish capital sufficient for all additions and improvements.

In many instances water bond issues have been voted down. Yet in those very instances there is little doubt that a 10 per cent increase in water rates would have been accepted without protest, had it been proposed to use the revenue thus derived for waterworks improvements and extensions. We therefore urge serious consideration of this plan, not only where bond issues have been, or are likely to be, rejected, but as a permanent policy in all growing cities, namely the plan of raising water rates sufficiently to provide a substantial part of the funds needed for additional plant and equipment.

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Certain Illogical Inferences as to Rain Cycles

NOT four years ago a distinguished hydraulic engineer not only denied the existence of any evidence of rain cycles in precipitation, but went so far as to say: "No one can foretell when the next very wet climatic year or group of wet years will occur. There is no possibility of any forecast thereof by the use of sunspot or any other cycles." It is this last sentence that we propose discussing briefly.

In the words of Galileo: "Who is willing to set limits to the human intellect?" The hydraulic engineer just referred to has published a sentence that virtually answers Galileo by saying: "I am willing to set limits to the human intellect."

Speaking of this very problem of weather cycles, Prof. Karl Pearson, in his "Grammar of Science," p. 105, says: "If we believe in the capacity of the reflective faculty for ultimately reducing to a brief formula or law all types of phenomena, if we believe in the co-ordination of perception and reflection, then the weather will not probably appear a very strong argument against our hypothesis. It must at least be confessed that the discovery of a hundred or a five hundred years' period in weather would sadly discomfort those who delight in assuming that some one group of perceptions at least must be beyond the analysis of the reflective faculty. Yet such a discovery would not now be more remarkable than that of the Chaldean Saros or eclipse period must have been to those who looked upon eclipses as an arbitrary interference with their perceptions, and prayed and drummed vigorously for a restoration of the light of sun or moon."

Few meteorologists publicly deny the possibility of long range weather forecasting, but most of them seem to regard it as an achievement possible only in the far distant future. One of the most eminent of them has recently said that hundreds of years more of gathering of weather data will probably be required before long range forecasting will be feasible. Logically such a statement has no more foundation than has the statement that reliable long range weather forecasting will never be possible. Who can prove the insufficiency of existing data? The argument of insufficient data is apt to be the excuse of the man who has either never tried to discover a scientific law or who has failed in his attempt.

Clayton, in his "World Weather," p. 378, gives a composite curve formed by combining 10 different but harmonic curves that are cyclic. And then he shows how a computer analyzed this composite curve into its 10 distinct cycles, by using a method analogous to Schuster's periodogram method. He says: "This curve, though drawn from the summation of only 10 harmonic periods, appears to be absolutely fortuitous, yet the analysis of the data (i. e., the composite curve) by a person who did not know the number, or length of the periods from which it was constructed gave the results in the table." The results in that table show that, for 9 out of the 10 periods, the deduced length of each period was within 3 per cent of its actual length. In the 10th case the analyst erred 18 per cent.

Careful inspection of Clayton's composite curve does not disclose a single one of the 10 cycles. It appears to be completely haphazard in its ups and downs, thus resembling many a rainfall curve. None the less it is not a fortuitous curve that Clayton has plotted. By what reasoning process, then, has any engineer or meteorologist come to the conclusion that rainfall curves are either fortuitous or not susceptible of analysis until vastly more data are available? Apparently such conclusions rest upon the false premise that rainfall cycles are so few in number and so pronounced in effect, that they must be discoverable by mere inspection or the simplest of analytical methods.

The editor has discovered, and in several cases rediscovered, more than 20 rainfall cycles. Many of these would have remained hidden had he not used the cyclogram method of analysis devised by Balfour Stewart, the great Scotch physicist. Schuster attempted to improve on the cyclogram with his periodogram, but the periodogram introduces the hypothesis that all the cycles are harmonic, which is not the case. Each planet causes three harmonic cycles of rainfall, and all rain cycles are roughly harmonic, but an assumption of perfect harmony for all of them is disastrous in any weather research. Indeed, the attempt to force all the cycles into perfect harmony or commensurability is apparently at the bottom of most of the failures to unsnarl the weather snarl. In addition to this, there is a confusion oscillation of the length of each weather cycle about a mean length, due not only to the eccentricity of the orbit of each planet whose magnetism affects our weather, but to the orbital motion of the earth itself. The earth is a moving target and the planets are moving gunboats firing magnetic rays at this moving target. But let the complexity be what it may, an analysis of each cycle is practicable. Then a subsequent synthesis will undoubtedly fit the rainfall curves with considerable accuracy.

H. P. Gillette

Raw Water Aeration at Danville, Va.

By HOWARD A. JOHNSON
Superintendent of Filtration, Danville, Va.

DANVILLE'S, Virginia's first pretense at a water system, was put into operation during the year 1881. This was nothing more or less than a steam pumping station on the banks of Dan River about a mile below the site of the present water purification plant, the system depending on a steam pump for the quantity of water and on household filters for the quality of the water.

Early Filtration Plant.—During the years 1904 and 1905 this pumping station was abandoned for a then modern filtration plant at the present site. This plant had a maximum capacity of 3 m.g.d. The plant at that time consisted of the following: ½ m.g.d. settling basin, 6 tub filters, and a 3 m.g.d. Snow steam pump. The raw water being dosed by means of solution feed and flowing by gravity directly into the coagulation basins. With very few changes this plant supplied the demands of the city until 1924. By 1924 the consumption of water had practically reached the capacity of the plant, with a small margin of safety, and it had become somewhat obsolete and inefficient.

Plant Rebuilt in 1924.—During 1924 this plant was practically entirely rebuilt under the engineering supervision of Hazen and Whipple, and increased to a maximum capacity of 6 m.g.d.

At this time the coagulation basins were enlarged from a capacity of ½ m.g.d. to a capacity of 1¼ m.g. Raw water aeration was introduced, two dry feed machines installed for feeding aluminum sulphate, a circular mixer constructed to insure proper mixing of the chemicals with water, the 6 tub filters replaced by 8 ¾ m.g.d. rapid sand filters with a total filter area of 1,724 sq. ft. or 215.5 sq. ft. per unit, a low lift raw water pump installed, and an electric high lift pump substituted for the steam pump, reserving the steam pump as an emergency standby unit.

The old plant received its water from the river by gravity, but on the enlargement of the plant it was necessary to install a low lift pump to supply the aerator and also to take care of the increase demand on the raw water line.

The Filters.—The rapid sand filters were constructed with a great deal of ingenuity and simplicity, mainly to cut down the cost of construction. All the 8 filters are operated practically as one filter in two banks, being controlled by one rate of flow gage and one loss of head gage. Each bank of 4 filters is supplied by one influent valve and drained by one drain valve. No re-wash valves were used. The effluents from the 8 filters are controlled by separate valves; thereby arranging for washing each of the 8 filters separately; although each bank of 4 filters must be drained preparatory to washing, simultaneously.

The wash water is supplied by means of an eductor, obtaining one-third of its water from the distribution reservoir and two-thirds of its water from the clear well at the plant. This gives a constant rate of wash of 26 in. per minute, which may be lowered but not raised.

The raw water aerator removes practically 80 per cent of the increase in CO_2 content due to the application of the coagulant. The remaining CO_2 is removed after filtration by the application of caustic soda, which in turn is controlled so as to leave the water with a phenol alkalinity of approximately 1 p.p.m. and a pH of around 8.3. Chlorination is accomplished by the use of two Type M.S.V. Wallace & Tiernan vacuum feed chlorinators.

The water is lifted to the distribution reservoirs by means of a 5 m.g.d. centrifugal pump powered by a 2,200 V. G. E. synchronous motor. A 2½ m.g.d. centrifugal pump, powered by a 2,200 V. induction motor, and the 3 m.g.d. steam pump constitute the auxiliary pumping equipment.

When the plant was remodeled and modernized in 1924 an aerator was installed prior to the coagulating basins. The aerator receives the dosed raw water supplied by a 5 m.g.d. centrifugal pump powered by a 2,200 V. G. E. induction motor operating under a head of 14 ft.

Pre-aeration was deemed advisable for several specific reasons: To promote coagulation, to improve the efficiency of filtration, to remove possible tastes and odors, and to aid in the reduction of CO_2 present in the water.

The Aerator.—The dosed water supplied by the low lift pump is diffused by 37 nozzles each with a $1\frac{3}{16}$ in. orifice, falling onto a floor space of 1,600 sq. ft. or 320 sq. feet per m.g.d. As stated before, this aerator removes approximately 80 per cent of the increase in CO_2 due to the dosing with aluminum sulphate, which in turn raises the pH value and delivers the water to the coagulation basins with practically the same CO_2 content as that of the raw water.

The raw water enters the plant with a CO_2 content of 1½ to 4 p.p.m. and a pH value of 6.8 to 7.2, depending on the condition of the river. Dosing increases the CO_2 content to from 2 and up depending on the amount of coagulant used. Aeration in turn lowers the CO_2 content to approximately that of the raw water.

Since the installation of pre-aeration a decided improvement in the coagulation has been noticed and a slight decrease in the alum consumption in grains per gallon.

Except in rare cases, and then for only a short period of time, it is now unnecessary to use an alkali to obtain the desired floc (soda ash being used when necessary) while before the installation of the aerator an alkali (lime being used at that time) was necessary practically at all times.

From the aerator floor the water flows by gravity, through the mixer to the remainder of the plant.

The following figures may be of interest relative to the plant as a whole:

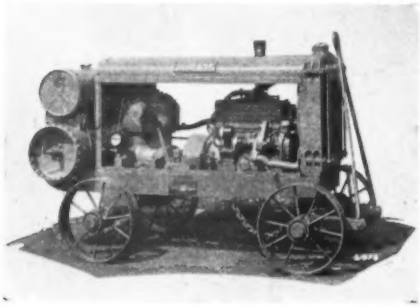
Number of filters	8
Filters areas (total)	1,724 sq. ft.
Capacity (maximum)	6 m.g.d.
Storage:	
Plant reservoir	0.5 m.g.
Distribution reservoirs	7.5 m.g.
Total	8.0 m.g.
Net capacity (computed)	4.69 m.g.d.
Net capacity	78.2 per cent
Filter yield	44 m.g. acre day
Rate of filtration	117 m.g. acre day

Acknowledgment—The foregoing is a paper presented at the annual meeting of the Virginia Water and Sewage Works Association.

New Equipment and Materials

Schramm Engine-Driven Compressor

The standard No. 72 Schramm compressor is a complete engine-driven unit embodying all the features found in larger Schramm outfits, and has a displacement of 72 cu. ft.



Schramm No. 72 Portable Engine-Driven Compressor

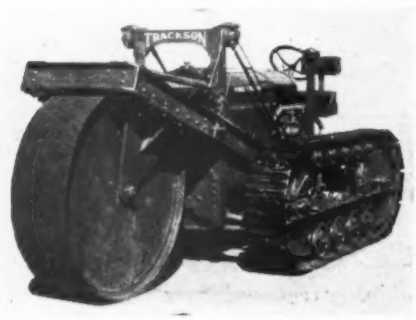
This size of compressor serves many purposes. First, it can be used as an auxiliary unit for replacing the larger compressors on work where only a one-tool outfit is needed; and second, it makes a good investment for the contractors who need only a small outfit for the occasional rock drilling, paving breaking, demolition work, clay digging, tamping, riveting and other work done by pneumatic tools on their jobs.

The outfit is completely housed with removable steel doors and equipped with extra-heavy A. S. M. E. riveted tank with fusible plugs, directly connected to the compressor by means of a heavy pipe with rugged expansion joints. The tanks are inspected and carry with them a certificate of inspection.

New Trackson Trench Roller

An interesting recent development in construction equipment is the new Trackson trench roller, illustrated here, which provides a simple, effective and economical method of packing down dirt over newly-laid cable, conduit or pipe line. This roller is manufactured by the Trackson Co., Milwaukee, Wis.

This roller is built for mounting on the Model DH Trackson McCormick-Deering crawler-tractor, as shown in the illustration. It consists of a wide steel roller filled with concrete, which weighs from 3,000 to 4,000 lb., the weight varying to meet the requirements of different soil conditions. For average jobs a 3,500-lb. roller is recommended.



Trackson Trench Roller

Interchangeability is a feature of Trackson front-end tractor equipment, and since the mechanical hoisting assembly of the trench roller is identical with that of the Trackson shovel and the Trackson bulldozer, it is an easy matter to detach any one of these attachments and mount another in its place. In this way a single power unit may be used for a number of purposes.

This outfit may be used for rolling over all kinds of underground lines without damaging the cable or casing, provided, of course, that sufficient dirt is thrown over the pipe before it is rolled. The first layer should be from 10 to 20 in. in depth, depending on the nature of the soil, and the rest of the dirt is usually rolled in 6-in. layers.

New ½-Yd. Convertible Excavator by Orton

A new small excavator has been developed recently by the Orton Crane & Shovel Co., Chicago, Ill. It is equipped with a 40-hp., 4-cylinder gasoline engine which is provided with an accelerator arranged for both hand and foot operation, electric starter, oil filter, air cleaner and other modern accessories.

New Orton Model 4 Excavator

Power is transmitted by means of a multiple-disc clutch, the transmission shaft being mounted on anti-friction bearings. Connecting the transmission shaft to the propelling clutch shaft is an enclosed alloy-steel chain with floating take-up. By use of the engine clutch the double-jaw propelling clutches can be shifted as easily as a friction clutch of the gear type, and the traveling speed can be varied from ⅝ to 3 m.p.h. A special main cutout clutch enables the operator to stop all of the machinery except the propelling mechanism when traveling, a decided advantage when going any considerable distance.

The treads are of the self-cleaning type, and are driven by heat-treated alloy-steel roller chains on large-diameter hardened sprockets, provision being made for take-up of both the treads and chains. Coil springs back up each set of treads, thus protecting the operating mechanism from undue strains and shocks, and distributing the weight of the machine uniformly on the shoes when traveling over uneven ground.

Steering is accomplished by a hand wheel in the cab, brakes being applied to either of the two differential shafts. The machine can be turned in a circle, the radius of which is equal to the center-to-center distance between the treads.

The shovel is equipped with a 16-ft. heavily-constructed and electrically-welded boom and a 12½-ft. electrically-welded dipper stick with numerous diaphragms. A special patented rope crowd does away with troubles incident to the adjustment of the length of the rope, and the dipper can be held in a fully extended position. Normal speed of the crowd is 85 ft. per minute.

The Model 4 excavator is readily convertible to shovel, crane, dragline, ditcher or skimmer, and changes to these attachments can be made in the field.

An extension of the cab for the operator's position gives a clear view of the work on both sides of the machine, and the levers are conveniently located. Each function of the Model 4 is controlled by a separate lever.

The Cranemobile

A new convertible machine—the "Cranemobile"—is now in production by Bay City Shovels, Inc., Bay City. Mich.

The Cranemobile is an adaptation of the Bay City crawler mounted tractor model. No change is made in the machinery, superstructure or booms and buckets. In place of crawlers heavy steel wheels with large solid rubber tires are substituted permitting faster travel speeds and eliminating crawler wear for long or fast moves. A special heavy duty forged Timken front axle is provided with roller bearings. Steering mechanism is provided under tractor end of machine. The Cranemobile is intended for any material handling job where a truck crane would normally be used or where a fast moving and operating machine is desired for work on hard or relatively smooth ground.

The tractor shovel is to be continued in production, as the Cranemobile is intended for another field of work, where hard surfaces conditions favor a rubber wheel mounted machine, rather than crawlers.

This machine is convertible and, in addition to standard crane attachments, such as clamshell, hook and block, electric magnet, etc., it is available with shovel dipper, trench hoe or skimmer bucket.

Three speeds forward up to seven miles an hour and one speed reverse are available.

Bay City Cranemobile

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

U. S. Pipe & Foundry Opens New Laboratories

The United States Pipe and Foundry Company is taking much justifiable pride in the opening of the new research laboratories, and recently conducted an inspection trip through the various departments for representatives of the trade paper press.

Every department was visited with the greatest interest and demonstrations and exhibits of apparatus and machines gave forceful testimony to the completeness of this new addition to the facilities of this organization.

In the Mettallographic Laboratories equipment was shown for examining the structure of metals up to several thousand diameters, and all accessories for rapid work such as printing machines, drying and washing machines, to enable the preparation of reports requiring photographic prints in a rapid and economical manner.

Studies are being made by the laboratories to develop better cement coatings with the entire elimination of free lime and a complete apparatus was exhibited for the study of cement in connection with the study of centrifugal lining of pipe.

The Sand Testing Department was visited where a method for determining moisture in sand by means of electrical and air currents was shown, and the strength and permeability of dry and green sand cores was also demonstrated.

The Chemical Department and the Physical Laboratory were filled with points of interest. The Physical Department has been so laid out that specimens can be machined promptly and results obtained with a minimum delay.

The following is a list of equipment to be found in the Physical Laboratory.

Test Machines

1. 50,000 lb. Amsler Universal Testing Machine.
2. Tinius Olsen Izod Impact Testing Machine.
3. One Inch Ring Impact Tester.
4. Olsen-Boyd Automatic Cement Tester 2,000 lb. cap.
5. Olsen Direct Motor-Driven Hydraulic Brinnell Hardness Tester.
6. Rockwell Hardness Tester.

Furnace

1. 25 K. W. Hoskins Electric Furnace with automatic temperature control.
2. 5 K. W. Hoskins Electrical Furnace with manual control.

Machine Tools

1. 15-in. South Bend Motor Driven Lathe.
2. No. 6 Gardner Disc Grinder.
3. Racine 12 in. x 12 in. Power Hack Saw.
4. Racine 4½ x 4½ Power Hack Saw.
5. Barnes 20 in. Swing Stationary Head Drill Press.
6. Milling Machine.

Special machines for the study of various pipe coatings as well as impact machines for testing full sections of pipe are located in the basement. A special experimental unit has also been provided in the Burlington works where melting experiments can be conducted on special iron mixes and other metals. The unit is arranged so that the Laboratory developments along any line can be carried out in small scale production without interfering with the regular operations of the plant.

New Research Laboratories of U. S. Pipe and Foundry Company

The Library, which may also be adapted for consultation purposes, is filled with a vast assortment of technical and scientific volumes. Complete facilities are available for the projection of motion pictures. The Library and offices of the Research Department occupy the entire second floor of the new addition.

The completeness of facilities and convenient arrangement makes the entire new building well suited for the work for which it was designed.

New Distributors for Chain Belt Co.

Chain Belt Company of Milwaukee announces the appointment of two new distributors in the Construction Equipment field, namely: the Alabama Machinery & Supply Company of Montgomery, Ala., and the Concrete Products Sales Company, Ltd., of Oakland, Cal.

A Convincing Demonstration

At the recent convention of the American Water Works Association held at Amarillo, Texas, the various midwestern distributors of Pomona pumps installed an interesting exhibit in the Herring Hotel. A complete operating unit actually producing water in the hotel lobby attracted the attention of all the delegates. Apparently it was a happy occasion for the Pomona representatives judging from the smiles.

H_2O Via A Pomona

Distributor representatives of Pomona Pump Company, reading from left to right: H. W. Ross, Fred H. Holmes, S. F. Smith, R. W. Butters, A. V. Shuler, W. G. Price, and Joe Baker.

Gas Products Association

E. L. Mills, sales manager of the Bastian-Blessing Company, was recently elected president of the Gas Products Association. In electing a manufacturer of oxy-acetylene welding and cutting apparatus to this office a departure was made from the usual practice of electing a manufacturer of oxygen gas.

Mr. Mills was instrumental in raising thousands of dollars for the production of films for the Association and also has supervision of their production. The films portray the development of welding which makes possible a single pipe which is a thousand miles long; welded steel tubing aircraft fuselage; and the welded pipe joints in skyscrapers and other buildings for carrying of steam, liquids and gases. The films have been shown in many parts of the world and are available for associations and clubs.

Headquarters of the Association are in Chicago and officers and directors include: A. J. Fausek, Modern Engineering Company; W. H. Ballance, Electrox Company; H. B. Pearson, Compressed Gases, Inc.; M. L. Goodrich, Swift & Company; W. D. Flannery, K-G Welding and Cutting Co., Inc.; O. E. Engler, The Balbach Company; L. F. Loutrel, Shawinigan Products Corp.; E. H. Smith, Commercial Gas Co.; E. J. Flood, Page Steel & Wire Co.; and Parker B. Francis, Kansas City Oxygen Gas Co.

American Hoist & Derrick Opens Indianapolis Office

The American Hoist & Derrick Company announces the removal of its Dayton office to Indianapolis, Ind. The new office is located at 703 New City Trust Building. Mr. I. R. Bailey will have charge of the sales of the "American Revolver" and Mr. Wm. M. Schoen will represent the entire line of "American" hoisting machinery.

Both Mr. Bailey and Mr. Schoen are well known in Indianapolis.

Cutler-Hammer, Inc., is now occupying new offices in Philadelphia located on the tenth floor of the Terminal Commerce Building, 401 North Broad Street. Mr. F. J. Burd is manager of the Philadelphia district, where warehouse facilities are maintained for stocking C-H products, including motor control, wiring device and safety switch items for the convenience of patrons.

Lecourtenay Company, Newark, N. J., manufacturers of centrifugal pumps, announce the appointment of Mr. F. J. Moran as Philadelphia District Manager with offices in the Witherspoon Building.

Mr. Moran has for the past fifteen years been engaged in sales work for the General Electric Company in Philadelphia and, prior to that in New York and Chicago. He is a graduate of Sheffield Scientific School, Yale University.

Staynew Filter Corporation has moved its factory and home office to 25 Leighton Avenue, Rochester, New York. This removal to new and larger quarters was made in order to enable them to better handle their increased business.

Mr. L. J. Belnap, president of Worthington Pump and Machinery Co.

Worthington Pump Takes Over Gilman Company

Announcement has been made of the acquisition of the Gilman Manufacturing Company of East Boston, Massachusetts, by the Worthington Pump and Machinery Corporation. It is stated that the Gilman line of rock drilling equipment logically supplements the Worthington line of feather valve air compressors, and will aid in the expansion of their line of pneumatic ser[illegible] to mines, quarries, contractors and industry, which will henceforth be manufactured under one head. The combined experience of the Worthington and Gilman engineers is assured for each installation.

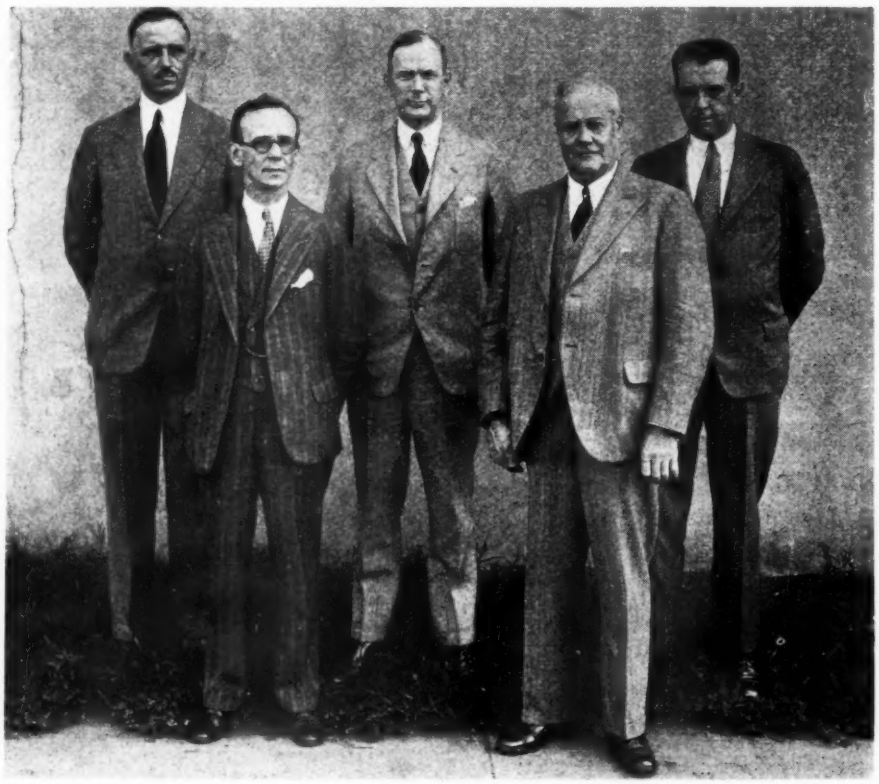
Although the Gilman products are already favorably known, the Worthington organization together with George H. Gilman and his staff, look forward to an increased prestige for the Gilman products under the new arrangement.

The general offices and works of the Worthington Pump and Machinery Company are located at Harrison, New Jersey, and branch offices are maintained in all the principal cities of the country and abroad.

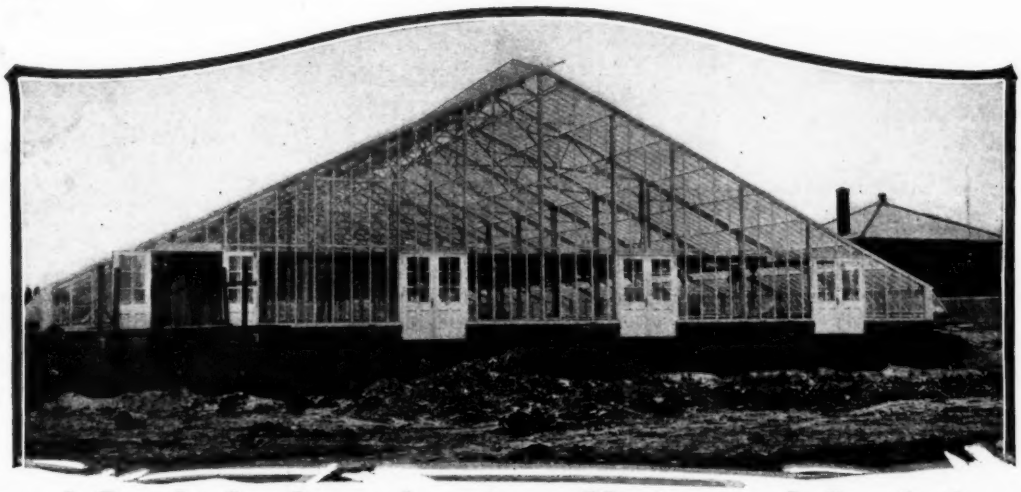
New Sales Representatives for Paradon Company

The appointment of the following representatives for the sale and service of Paradon chlorinators has been announced by the Paradon Manufacturing Company of Arlington, New Jersey: For Florida (Jacksonville district) W. Austin Smith, 1207 Lynch Building, Jacksonville; for Tennessee (Memphis district) C. Fuson, 246 Court Avenue, Memphis; for Kansas district, The Smiley Equipment Company, Kansas City, Mo.

Federal Cement Tile Company of Chicago announces that it has acquired the American Cement Tile Manufacturing Company. Executive and general offices will be at Chicago with additional sales offices in New York, Philadelphia, Pittsburgh, Detroit, Boston, Buffalo, Birmingham and other cities. Plants are located in Hammond, Indiana; Lincoln, New Jersey; Wampum, Pennsylvania and Birmingham, Alabama.



Gilman Company Staff Now Members of Worthington Pump & Machinery Co.
Left to Right: Roy S. Hutchison, Charles A. Hirschberg, George H. Gilman, James R. Elmendorf, and Raymond J. Berke



The City of Dunkirk chose American-Moninger sludge bed enclosures

Since 1869

TWO American-Moninger glass all-steel sludge bed enclosures have recently been installed at the new sludge bed plant of the City of Dunkirk, New York. Special consideration was given to American-Moninger sludge bed enclosure on account of the all-steel acid and fume resisting construction built according to the approved engineering standards and practice which gives the positive assurance of the safety and strength of these structures.

When planning new sludge bed plants ask for an American-Moninger Engineer to discuss the plans with you and furnish preliminary sketches and specifications before you build. He will have some valuable suggestions for you. You will be under no obligation.

American-Moninger Greenhouse Manufacturing Company

Cleveland, Ohio., 11125 Lake Avenue

SOUTHWEST OFFICE
Oklahoma City, Okla., 2611 North Dewey St.

1365 Flushing Avenue
Brooklyn, New York

WESTERN OFFICE
Chicago, Illinois
1313 W. Randolph Street

No Water Hammer—No Bursted Mains

GOLDEN-ANDERSON

Automatic "Cushioned" Controlling Altitude Valves Cushion All Water Surges

Automatically maintain a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks.

"Three Ways of Closing These Valves":
1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By hand.

May also be arranged to close automatically when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. Write for details.

REMEMBER
Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

GOLDEN-ANDERSON VALVE SPECIALTY COMPANY
1329 Fulton Bldg., Pittsburgh, Pa.

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves

Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ⅛-inch to ¾-inch variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½-inch to 24 inches

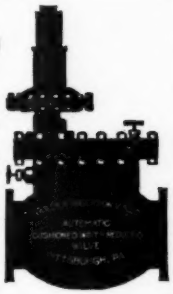
GOLDEN-ANDERSON

Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-inches.

GOLDEN-ANDERSON

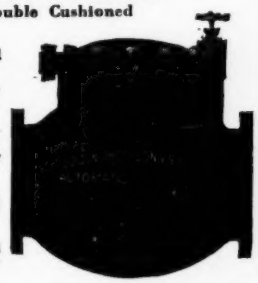
Pat. Automatic Cushioned Water Pressure Regulating Valves



1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

GOLDEN-ANDERSON

Pat. Automatic Double Cushioned Check Valves



1. Especially adapted for water service.
2. For high or low pressure.
3. Thoroughly cushioned. No chattering, hammering, or sticking.
4. Globe or angle patterns up to 24 inches.
5. Especially adapted for hydraulic elevator service.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Float Valves

1. Automatically maintain uniform water levels in tanks, standpipe, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—most satisfactory float valves known.
4. No metal - to-metal seats—no water hammer or shock.
5. Cushioned by air and water.

Sizes ¼" to 24".

W. S. Stewart to Represent Lincoln Electric in Cleveland

Announcement has been made of the appointment of W. S. Stewart, formerly in charge of the Pacific Coast offices of the Lincoln-Electric Company, to the position of district manager in charge of the Cleveland territory with offices at the factory, Coit Road and Kirby Avenue.

Mr. Stewart is a graduate of Yale University where he took a prominent part in athletics. He spent a number of years in the factory of the Lincoln company studying welding and was then transferred to the automatic arc welding department. From this department he was transferred to the Pacific Coast to handle sales. His wide experience has thoroughly qualified him for his new position.

Sales Personnel Changes in Wickwire Spencer Steel

A. A. Wilmot, who has been a member of the New York Sales Department of the Wickwire Spencer Steel Company for the past five years has been made assistant sales manager in charge of structural products at the Chicago office, 208 South La Salle Street, according to recent announcement.

G. L. Crawford, who has been a member of the sales staff at Chicago for the structural products during the past four years has been transferred to the office at Tulsa, Oklahoma, where he has been made assistant sales manager in charge of structural products. The Tulsa office is located at 1304 The Philtower.

B. L. Donahue Made District Manager

Cutler-Hammer, Inc., of Milwaukee, Wisconsin, manufacturers of electric control apparatus, has announced the

B. L. Donahue

appointment of B. L. Donahue as manager of the Buffalo district office. Mr. Donahue succeeds B. A. Hansen, who has resigned.

Mr. Donahue has been connected with the Pittsburgh branch of the Cutler-Hammer company for the past eight years and is well known in the electrical field. He is a graduate of Penn State College, and holds the degree of B. S. in electrical engineering. He is a member of the Association of Iron and Steel Engineers, and of Sigma Tau Engineering fraternity.

Service Exchange has been helpful in securing desirable representation for the products of many manufacturers and in assisting distributors in building up their lines.

They Managed the Show

Left to right: O. E. Andreen, A. E. Loder, L. J. Fletcher, T. R. Farley and H. H. Sunderlin. These are the men who were responsible for the successful planning and carrying out of the Caterpillar Equipment Show recently held in Peoria, Illinois, by the Caterpillar Company.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of Water Works and Sewerage publishe monthly at Chicago, Illinois, for October 1, 193
State of Illinois } ss.
County of Cook }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared E. S. Gillette, who, having been duly sworn according to law, deposes and says that he is the business manager of Water Works and Sewerage and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Gillette Publishing Company, 221 East 20th St., Chicago, Ill.; Editor, H. P. Gillette, 221 East 20th St., Chicago, Ill.; Managing Editor, C. T. Murray, 221 East 20th St., Chicago, Ill.; Business Manager, E. S. Gillette, 221 East 20th St., Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Gillette Publishing Company, 221 East 20th St., Chicago, Ill.; H. P. Gillette, 221 East 20th St., Chicago, Ill.; E. S. Gillette, 221 East 20th St., Chicago, Ill.; Mrs. R. W. Hume, 303 S. Stone Avenue, LaGrange, Ill.; Winifred Gillette, 1125 Oak Grove Ave., San Marino, Calif.; Commonwealth Title Insurance & Trust Co., Chestnut and 12th Sts., Philadelphia, Pa.; Louise Forsythe, 13 E. Windermere Terrace, Lansdowne, Pa.; LaVerne Louer Hellyer, Ambassador Hotel, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

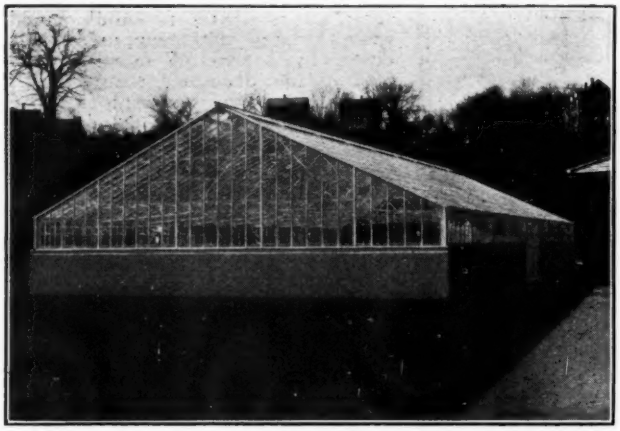
5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is (This information is required from daily publications only.)

E. S. GLLETTE,
(Signature of business manager.)

Sworn to and subscribed before me this 26th day of Sept. 1930.

KITTIE C. WOULFE,
(Seal.) Notary Public.

(My commission expires Feb. 8, 1934.)



This sludge bed is attractive, odorless and twice as efficient

King Sludge Bed Enclosures offer notable advantages over the older method of open-bed drying—advantages which the progressive community is quick to recognize.

In the first place, King Enclosures remove the only esthetic objections to disposal plants, viz., ugly appearance and odor. The King equipped plant is as attractive as a greenhouse, and all odors are effectively controlled by a special ventilation.

Sludge beds are doubled (sometimes trebled!) in capacity by King Enclosures. The drying continues regardless of the weather and sludge may be run to greater depths. Twice the population can be served with the same beds!

Examine the many King benefits. The houses themselves are rigidly constructed of durable, copper-bearing steel side posts. The steel rafters are spaced on 8'5" centers giving more supports per hundred feet of glass. All woodwork is of genuine, clear heart California Redwood, that wood which so superbly resists rot and decay century after century. Send for full information. No obligation!

The King Enclosure above is at the City of New London, Conn. Disposal Plant. Engineer: G. E. Watters.

OUR CATALOGUE IS FILED IN SWEET'S

KING CONSTRUCTION COMPANY

533 Wheatfield Street North Tonawanda, N. Y.

NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS. SCRANTON, PA.
TOLEDO, OHIO SCHENECTADY, N. Y. BRIDEPORT, CONN.

Bourbon Fire Hydrants, Gate Valves and Extension Valve Boxes

Water Works and Fire Department Supplies

The Bourbon Copper and Brass Works Co.

618-620 E. Front St. Cincinnati, Ohio

SIMPLEX METERS

Accurate - Reliable - Simple
Easy to Check and Adjust

VENTURI TYPE

Manufacturers of

Meters and Controllers of Venturi Type; Gauges; Air and Vacuum Valves; Air Release Valves; and other Water-Works Devices

Write for Bulletins

SIMPLEX VALVE & METER CO.

6749 Upland Street Philadelphia, Pa.

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives of their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Manufacturer's representative located in New York City, now handling pumping machinery, would like to take on two or three additional lines serving the same field as his present account.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Water works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Water Works equipment distributor, covering northeastern Indiana, would like to secure representation of a line of chlorinators.

Wanted agency for any type of building specialties or contractors' machinery except mixers. Twenty years experience. Familiar with all types of contractors' machinery. Could act as sales manager for Atlantic Coast line with dealers.

West Coast distributing organization equipped to take on additional lines of equipment and supplies for water works and sewerage field.

Machinery distributor, established in Porto Rico and Santo Domingo, would be pleased to make arrangements to take on new lines in these territories.

Manufacturer's representative, covering Massachusetts, Rhode Island and southern New Hampshire, would like to secure line of speed reducers and gears.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

▼

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

▼

Link-Belt Prepares for Future Business

Mr. Alfred Kauffmann, president of the Link-Belt, stated recently when interviewed: "Now, during the slack production period, is the time to perfect manufacturing processes and to prepare for future business. We believe in practicing what we preach."

In accordance with the policy expressed above a contract has just been closed for a powdered coal system entailing an expenditure of $125,000, for the Indianapolis foundry of this company. This improvement follows closelv upon the completion of a new factory at Toronto, and the complete new plant for the Pacific Division at San Francisco.

A building to house the new coal system and alterations in the plant are a part of the improvements planned for at Indianapolis, where Link-Belt chains for elevating and conveying are made. It is said that the system will modernize the process of firing the melting and annealing furnaces and the heating of the boilers.

▼

National Carbon Company to Sell "Gredag" Products

The Carbon Sales Division of the National Carbon Company, with headquarters in Cleveland, Ohio, which has been active for many years in the sales and distribution of carbon products, ha taken over the distribution of "Gredag" lubricants manufactured by the Acheson Graphite Corporation, a unit of the Union Carbide and Carbon organization.

It is stated that the many contacts with industrial plants and distributors of industrial products throughout the country which the National Carbon company maintains makes the addition of the line of lubricants a logical step.

Branch offices and service plants of the Carbon Sales Division are located in New York City, Pittsburgh, Birmingham, Chicago and San Francisco.

▼

The Hercules Motor Corporation of Canton, Ohio, manufacturers of heavy-duty engines, announce a change in the address of the Hercules European representatives. Hereafter the headquarters of the Automotive Products Company, sole distributors of Hercules Engines and Power Units for Great Britain and Continental Europe, exclusive of U. S. S. R., will be located at Brock House, Langham St., London, W.1., England.